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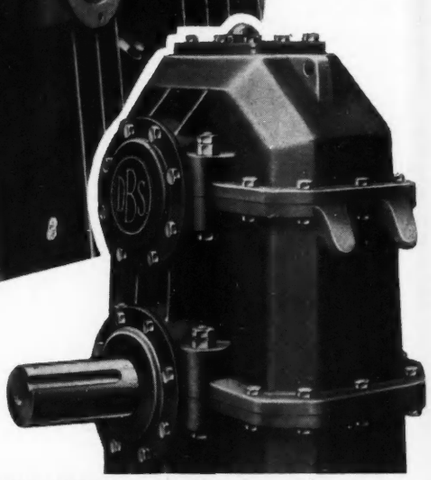

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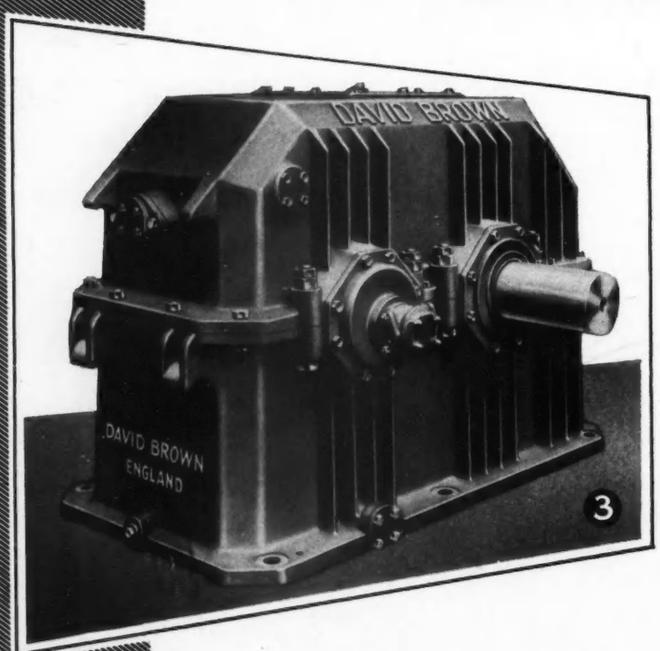

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ENGINEERING

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Vol. 178 No. 4636 DECEMBER 3, 1954

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THE BEST BRAINS

To play its vast role in modern life successfully, industry requires for its management and leadership a fair share of the best brains; but in order to secure the best brains, it must provide them with a challenge, with work that will engage their interest and tax their ability to the full. This industry can do; it is to-day "the greatest single human and economic activity," offering its prospective leaders heavy responsibility and demanding of them the broadest talent.

Where are the best brains to be found? At one time, industry received with each apprentice intake a certain number of boys of school-leaving age whose ability and intelligence would later fit them for managerial positions; to-day, owing to changes in the educational system, this number is much reduced. Those qualities which would formerly have secured promotion within the factory now qualify a young man for further education, and thus, instead of taking apprenticeships, a large proportion of industry's potential managers now remain at school until a later age and then proceed to universities. Consequently, if industry is to continue to be led by the most able people, it must turn to the universities for some, at least, of its recruits.

It has been estimated that, whereas in 1912 30,000 potential managers sought employment straight from school, in 1951 only 11,000 did so; the remainder would presumably only become available to industry after graduation.

The introduction of university graduates into an industrial organisation presents numerous problems. The graduate himself is many years behind his contemporaries in industrial experience and is unaccustomed to factory discipline and practices. To many of his new colleagues his arrival will seem to prejudice their own chances of promotion, and discontent aroused in this way can have serious consequences. It is important, therefore, that before the graduate is given any seniority he must prove his worth to his fellows and on no account must he be allowed to appear a privileged person. It may also be profitable to include on the selection board those departmental heads with whom the successful candidates will subsequently work, so that they may share responsibility in the choices made.

During his probationary period, it is common practice for the graduate to undergo a course of preliminary training, and many companies already offer excellent training schemes—normally of two years' duration—for both arts and science graduates of universities. These training courses should be carefully planned; not only has the graduate a great deal to learn, but nothing creates disillusion more quickly than boredom, and in preparing a curriculum it should be borne in mind that the graduate is considerably older than the average apprentice and has had the opportunity, at least, to develop a more active mind.

Quickness to learn should be a common ability of all graduates, of the arts graduate no less than the scientist or engineer, and industry has many posts which can be successfully filled by men who, though unqualified technically, have received a university education. Tradition, associated prestige and lucrative scholarships lead a very high proportion of university students to read arts subjects, and if the best selection of future industrial managers is to be made many must come from this source.

However, the view that the arts graduate is in some way better qualified for management than his technically trained colleague should be examined with caution. Scientific men are in such great demand for scientific posts that expediency may lead to their being overlooked as potential managers, and because it is convenient to do so, the arts man may frequently, but perhaps unjustifiably, be preferred.

Many of these points are discussed in two booklets published by the Federation of British Industries, details of which are given in the Books Received column this week. One, entitled *A Career for the Graduate in Industry*, is addressed to the undergraduate and describes the nature of industry and the opportunities it offers, giving notes on prospects and salaries. The other, *Industry and the Graduate*, is intended for industry itself and explains why industry must recruit more of its employees from the universities. The second booklet also suggests how science and arts graduates may be recruited, providing for this purpose a list of university appointments boards, and indicates how graduates should spend their initial years in industry.

The appeal made in the second booklet is to small as well as large firms; all branches of industry can profit by making use of the graduate. Attention is also drawn to the importance of selection and it is pointed out that the value of a machine depreciates whereas that of man increases with his experience; nevertheless often in industry more care is taken in choosing a new machine than a new employee. No matter how well equipped a works may be, its success depends ultimately upon the men who control it. The graduate, too, may profit from his entry into industry, which can provide him with a task worthy of his talent. The graduate has been taught to think; industry can give him something to think about.

Weekly Survey

ENGINEERS AND THE BUDGET

This is the season when trade organisations submit their views on the Budget for next year to the Chancellor of the Exchequer. Last week the Engineering Industries Association published a considered document for the Chancellor's examination which incorporated a programme of taxation relief and incentives to be brought into operation over a period of time. It is, indeed, a merit of the Association's submission that although its argument is much concerned with the need for increasing the profit incentive, it does not ask for sweeping reliefs in the immediate future.

It points out that the level of personal consumption in the country is rising steadily, and that this has been accompanied by an improvement in the level of personal savings. If the level of personal consumption is to go on increasing, says the document, and if an adequate rate of personal savings is to be maintained, a greater volume and efficiency in national production and stability of the price level is essential. High taxation restricts the amount of capital available for investment and acts as a deterrent on further effort. Reductions in the taxation of industrial profits, of personal incomes and of indirect taxation should maintain competitive prices for export, more funds for capital investment, stabilisation of the cost of living and fewer demands for higher wage rates where these are not justified by increased production. The Association suggests a reduction in the standard rate of income tax, lower purchase tax, lower petrol duty, lower profits tax, a measure of sur-tax relief, the adjustment of the personal allowances by a change in the exemption limit, lower taxation of retirement benefits for self-employed persons and directors of controlled companies, and modifications in death duties. This is a formidable list of concessions to place before any Chancellor of the Exchequer, and it only makes sense if it is part of a long-term dismantling and simplification of the system of taxation. Such wider issues cannot be considered until the report of the Royal Commission on Taxation is published.

It is probable that the next Budget will have an electioneering flavour about it. Mr. Butler gave very little away last April, although the industrial boom was already in sight; there may, therefore, be all the more to give away in April next year. The Chancellor's problem will be whom to favour without surrendering most of his revenue, which is required for the enormous overheads in the shape of the social services, defence and the consolidative services. It is to be feared that whereas the trained intellect of the engineer sees in the present fiscal position an opportunity for a gradual decline in taxation which might be almost mathematical in its precision, the Chancellor of the Exchequer will see the marginal constituencies.

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HELICOPTER DEVELOPMENT

The announcement by Sir Richard Fairey last week that the Fairey Aviation Company, Limited, have been given a contract by the Ministry of Supply to build an ultra-light helicopter is further evidence of the intensified effort being made to develop rotor aircraft in this country. The military authorities and civil airline authorities in recent months have both complained that whereas their needs for helicopters are urgent there was little prospect of these being met quickly from British sources. In Korea, Malaya and Kenya the helicopter has proved invaluable. The Navy, who will require them in increasing numbers, have ordered 100 twin-rotor Bristol 173 helicopters, and British European Airways have ordered two Westland S-55 helicopters to be used on the service between London Airport and the South Bank. This is only the first stage of a helicopter network covering 2,000 route miles which has been tentatively planned. No details have been disclosed of the new Fairey helicopter, but Sir Richard has said that it was hoped that it would meet Army requirements, and, in the longer view, interest the powers of the North Atlantic Treaty Organisation. What the Army requirements are likely to be cannot be easily determined at this stage, but they should become clearer as the work of the newly-formed joint experimental station of the Army and Royal Air Force proceeds. This is being set up at the School of Land-Air Warfare at Old Sarum to study the use of helicopters in providing greater mobility for the Army in the field.

Sir Richard has also revealed that the Fairey Aviation company have received an order for another prototype of their large helicopter, the Rotodyne, with " a somewhat different internal arrangement." The Rotodyne meets the British European Airways' specification for a large 40 to 50-seater rotor coach or " BEAline bus " upon which the fruition of B.E.A. plans for a network of 2,000 routes miles will depend. Because of the inadequate funds devoted to helicopter development in the past, it will be difficult for British aircraft manufacturers to deliver in large quantities as quickly as some operators require them. Ministry of Supply research and development expenditure will, however, reach £2·5 millions this year, eight times as much as in 1952, and will be further increased in 1955. By 1960, British aircraft manufacturers should be capable of offering, in quantity, a range of helicopters which will keep British operators in the forefront in this type of aviation.

★ ★ ★

COPPER MINING

Rising costs of copper mining have been a common theme in the speeches of two chairmen of copper mining companies in the last week or so. Mr. R. L. Prain, of Rhodesian Selection Trust, has emphasised to shareholders the rising trend of costs and the chronic difficulties with fuel, rail and power supplies in the Copperbelt of Northern Rhodesia. Another feature tending to keep costs higher, in Mr. Prain's opinion, is the size of the replacement programme which will shortly be due. Sir Ernest Oppenheimer, of Rhokana Corporation, was perhaps rather more optimistic about the trends of costs, commenting on the fact that labour-saving devices have been increased to counter higher wage costs, but it is apparent from Rhokana's experience that the rising prices of materials and labour have made inroads into profits.

Both chairmen have been concerned about the impasse between white labour and African which has now reached a critical phase in the Copperbelt. The report of the Board of Inquiry set up by the Northern Rhodesian Government to inquire into the advancement of Africans in the copper mining industry was published in October. Its conclusions were a triumph for commonsense in a situation where commonsense is unfortunately at a serious discount. It finished up with the warning that if the Union's contention for giving the African the same rate for the job as the European was put into effect, it would prevent the advancement of the African and disrupt the African wage structure. The Board argued that there was a reasonable case for wage differentiation between Africans and Europeans on the same job; it remains to be seen if the white Union is prepared to compromise on the principle of the " rate for the job " in order to give the African worker the initial impetus for improving his skill. It was clear from Mr. Prain's remarks that he thinks that the solution to the problem of African advancement is fundamental to the proper development of the Northern Rhodesian copper industry.

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EUROPEAN STEEL COMMUNITY

The European Community for Coal and Steel issued last week the first of a new series of information bulletins which should prove of interest to those people in the United Kingdom who concern themselves with the economics of world markets for iron and steel. The first issue reviews the progress—" slow but sure "—that the High Authority has made since the last issue of the old series of bulletins was published in June, 1954. Since that date a common market has been established in special steels and now exists for all the products within the Community's sphere—coal, iron ore, scrap, steel and special steels. Trade among participating countries, Belgium, France, Italy, Luxembourg and the Netherlands, has increased very satisfactorily since the establishment of the Community in 1952. Output of coal, iron and steel in those countries during the year ended July, 1952, amounted to 1·4 million tons; this increased to 1·8 million tons in the year ended July, 1953, and 2 million tons in the year ended July, 1954. Subsidies and rebates to the national industries are being " steadily whittled away." In Germany rebates amounting to £20 millions a year made by the coal mines to large consumers, such as the railways and shipping companies, have been abolished and in France subsidies on imported coal have been halved. Trade in steel has increased by about 30 per cent. during the last two years.

One of the results of the opening of the common market for special steel may be a growth in specialisation. Some progress has already taken place, and production is becoming more concentrated. In France, for example, four large mergers have taken place and three companies now control 55 per cent. of the country's 12 million tons of steel capacity. The bulletin lays stress on the supra-national character of the organisation, arguing that representatives in the Common Assembly of the High Authority tend to vote less and less in national groups and more according to party affiliations.

Prices have remained fairly stable under the ceilings fixed by the High Authority and, so far as steel is concerned, have remained at a slightly lower level than immediately before the common market, despite an all-round increase in demand. Since the establishment of the Community, however, very favourable conditions have prevailed which have doubtless considerably eased the delegates' task. The steel market recovered after a slight recession in 1953, and until now coal has been in short supply. The bulletin states that there are considerable stocks at the pitheads—about 15 million tons—but concludes that since general production is rising, this development is due more to the long-term tendency of oil, hydro-electricity and natural gas to replace coal, than to any other factor. This, however, constitutes a problem which may be difficult to solve. " Some experts have gone so far as to suggest a ' Power Steel Community '." There is no doubt that the High Authority will be required to take into account the other forms of fuel and power competing with coal in the planning of its long-term programme.

The increase in competition between member countries will test the Community's organisation. The remarks in the bulletin concerning " a fair trading code " and an anti-cartel law show that the Community are well aware of the difficulties involved.

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WELDING ALUMINIUM AND STAINLESS STEEL

Although the firm of Davey, Paxman and Company, Limited, of Colchester, are now probably best known for the manufacture of Diesel engines, for the first 60 years of their existence they were mainly concerned with steam and general engineering. They were the first makers of the well-known Economic boiler, production of which began in 1875. Before the first World War the production of oil engines was considered, but they were not made until 1925.

In spite of the growth of the Diesel engine side, the general engineering work has never been

abandoned; boilers and rotary filters are being made in considerable numbers. Fabrication by welding is now being employed in many phases of the work, particularly in the fabrication of stainless-steel vessels and aluminium frameworks. During a recent visit to the works examples of both techniques were shown.

The welding of light-alloy engine bedplates and sumps is carried out using an inert-gas shielded-arc process. An underbase for a type Y.H.A. engine for marine work was shown; it was made from 1-in. plate of 5 per cent. magnesium-aluminium alloy. The bearer bars are made of 4 in. by 2½ in. bars and 12 in. by 4 in. channels. In contrast, the oil sump was made of sheet only $\frac{3}{16}$ in. thick.

The same process is used for work in stainless steel. Many of the rotors for the rotary vacuum filters are of 18/8 stainless steel, and have to be built up in segments to give the required internal form. Others are of mild steel and rubber lined to prevent corrosion when handling acid liquors. Welding is also employed in the manufacture of the Bird centrifugal filters, which are made under licence. They consist basically of an outer cone which revolves at a fairly high speed, its axis being horizontal, and an inner screw tapered to fit the cone and revolving in the same direction but not quite so fast. The thread of the screw is welded around a cylinder, to the centre of which the slurry to be filtered is fed. About halfway along the cylinder holes pass the slurry into the outer portion for the centrifugal forces to separate the liquid from the solid. Under these forces the liquid flows to the larger end of the cone where it is discharged and the screw forces the solids along to the smaller end, where they are discharged. In this way a continuous filtering action is achieved.

The central cylinder, made up of two portions of different diameters, is formed from half-sections welded together. Similarly, the outer core is made of two pressings welded longitudinally, both items being in stainless steel. The screw thread is welded around the cylinder and has a hard facing to reduce wear.

Various items of chemical plant are made, including pressure vessels in stainless or mild steel. For mild-steel fabrication, the submerged-arc welding process is used as, for example, in the manufacture of boiler flues and all-welded boilers. Complete Diesel engine blocks are fabricated from steel plate, flame cut and welded together.

* * *

RETENTION MONEYS

The custom in the civil engineering industry of paying the contractor on a monthly certificate, less a sum to cover eventualities, is to be preferred to the possible alternatives. This is the main conclusion of the working party appointed to examine the procedure concerning "retention moneys" on building and civil-engineering contracts; their report has been published by H.M. Stationery Office, price 6*d.* net.

It is usual in these industries for the client to finance the work during its progress by paying the contractor for the greater part, 90 or 95 per cent., of the completed work and for the unused materials on site at the end of each working month. The remainder of the payments, subject to an agreed upper limit, is retained by the client to safeguard against extra expense which might be incurred in the event of the contractor's default, or to meet the cost of remedying any defects which develop within a reasonable time after completion of the works, usually six or twelve months.

It is the opinion of the working party that the principal objection to all the alternatives—various forms of bonds and guarantees—is the necessity of introducing a third party such as a bank, insurance company or financial trust house. To date, disputes between the employer (on behalf of the client) and the contractor have been settled by good sense and maybe by arbitration between the two parties concerned, both of whom are fully conversant with the type of problem involved. The advent of a third party of an essentially financial—as opposed to technical—character is feared likely to lead to more arbitration and litigation with its attendant costs. All the alternatives are also thought to involve a net addition to the cost of the work.

It is noted in the report that the total payment outstanding may often be substantially larger than the maximum retention money provided for in the contract; this, it is pointed out, is often due to delays of payment because of inadequate planning resulting in tenders based on approximate bills of quantities and extensive remeasurement, a method of building described as an "expensive luxury." The report ends with two points: that, in the interest of all concerned, the sum retained should be the minimum required by the circumstances of each job, and that a concerted drive should be made to ensure that all advances claimable under the terms of contracts are valued realistically and paid promptly.

* * *

QUALMS AT M.I.T.

The dilemma facing academic scientists and technologists to-day, especially in the United States, is emphasised in the report of the President of Massachusetts Institute of Technology for the year ended October 1, 1954. Dr. J. R. Killian draws attention to the fact that the Federal Government now spends about two billion dollars a year on research and development, most of it relating to defence. As a result the Government is now the principal sponsor of university research in the United States. The effects of this vast expenditure on a technological institution such as M.I.T. are well illustrated by a chart showing the major sources of income and expenditure last year. Nearly 65 per cent. of income came from sponsored research contracts and these figures do not include the operating of the Division of Defence Laboratories. Among the latter were the famous Lincoln Project on Continental Defence. A great deal of this work is subject to security regulations; and the recognition that, although the use of science for defence is necessary, it is not a natural or satisfying use, has led to the decision to build an unclassified nuclear reactor for non-military purposes.

Dr. Killian fears that the scale of Government-sponsored research may endanger independence of science and freedom of educational institutions. So far, he claims that this hazard has been avoided, but the hazard remains and calls for constant vigilance and wisdom to combat it.

Arising out of the same factors, the work and methods of the scientist have begun to produce popular reactions of fear, uneasiness and misunderstanding. One of the responsibilities of M.I.T. is to demonstrate and to symbolise the beneficent nature of science and creative intelligence. It is no doubt with these developments in mind that M.I.T. is trying to break down the barriers between the conventional academic departments, between the scientists and the engineers and between the engineers and the students of the humanities and the social sciences. The claim is made that a modern university can and should be built round the teaching of applied science and that M.I.T. may become the prototype of this new kind of university.

The number of students in 1953-54 was 5,183, of whom 1,955 were graduate students; 596 foreign students came from 76 countries. The total of faculty, students and all other staff was 11,500; a figure which includes those working in the Defence Laboratories. In spite of an expected increase in the numbers of applicants who will be seeking admission to the college in the next five years, M.I.T. feels that, without marked change in structure and a great increase in resources, it cannot grow much bigger and still maintain its present standards. The problem of resources for further expansion highlights the problem of relationship with Government, with its continually increasing demand for more scientists and engineers, which is added to the demand created by the growing use of research and advanced technology in industry. As in Britain, a vicious circle is being formed, with insufficient scientists and engineers graduating from the colleges and, as a result, a growing scarcity of science teachers in the schools. As with so many things on the two sides of the Atlantic, the problem is the same even if the scale is different.

* * *

WATER AND POWER IN INDIA

The problem of harnessing water supplies with the dual object of preventing flood damage and of providing irrigation facilities and hydro-electric power is one which exercises engineers in most countries throughout the world, but is perhaps particularly acute in India. Mr. G. L. Nanda, Indian Minister for Planning, Irrigation and Power, recently said that this year's floods had affected an area of 25,650 square miles and nearly 9½ million people. He announced that a Central Flood Control Board had been set up with the object of drawing up and implementing a national flood control programme estimated to cost Rs 1,750 million.

Later, addressing the first meeting of the Co-ordination Board on River Valley Projects, Mr. Nanda said that the aim of the first Five Year Plan and the two Five Year Plans that would follow it was to increase the proportion of land irrigated from 18 per cent. to 40 per cent. and the installed electricity generating capacity from 1·7 million kW to 8·7 million kW at a cost of Rs 20,000 million. The importance attached to irrigation and power projects under the first Five Year Plan is shown by the fact that these accounted for 32·5 per cent. of the total planned outlay. When the Plan ends in 1956 it is claimed that 28 per cent. of the cultivable land will be irrigated and generating capacity will have been increased to 3·9 million kW, representing increases of 58 per cent. and 131 per cent. respectively compared with the figures for 1950-51.

Although substantial progress has already been made, serious doubts have been expressed as to India's ability to finance the full programme. The International Monetary Fund's mission which visited the country in 1953 found that the standard of living had deteriorated since before the war and expressed the view that, while development was vital, the living standards of the lower income groups left no margin from which to finance the five-year development plans. Nevertheless, the Finance Minister has not been afraid to increase taxation and although the current year is expected to produce an overall deficit of £200 million the country is not yet showing inflationary symptoms and prices have in fact dropped by about 6 per cent. The reasons are that industrial production has been running at a record level and agricultural output is also expected to be higher than ever before. It the full development plans are to be carried out, however, Government expenditure will increase very much more rapidly over the next few years. It remains to be seen whether industrial and agricultural production can be expanded sufficiently rapidly to absorb the extra money created to finance the deficit on capital account.

* * *

ADVANCE INFORMATION

For those that have ears to hear, the Beaver Committee report on air pollution is tantamount to advance information on the re-equipment and redesign of plant that will almost certainly be required when the law is amended. All users of boilers and other smoke-producing plant are affected but, in addition, makers of boilers, locomotives, road vehicles, instruments, etc., will doubtless see opportunities for future developments in their business. Opportunities for further research have also been listed by the Committee. Extracts of engineering interest are given elsewhere in this issue of ENGINEERING.

TECHNICAL EVIDENCE AT THE COMET INQUIRY

Concluded from page 682

When the inquiry into the loss of the two Comets was resumed in London on Monday, November 22, Sir Hartley Shawcross recalled that he had been addressing the court on the question of fatigue and submitting that so far as Comet Yoke Peter was concerned there was no doubt that the substantial cause was fatigue in the metal skin of the fuselage.

On the question of where the fatigue originated, Sir Hartley said that the only choice was between the starboard rear corner of the ADF hatch and the port forward corner of it. All the positive evidence of the experts was in favour of the starboard rear corner. The theory that the port forward corner might be a site or origin was relevant in that there was a manufacturing crack there.

Sir Hartley, referring to publicity which had been given to the discovery of manufacturing cracks in Comets, suggested that people might be concerned about them and might think that they were responsible for accidents.

Lord Cohen: It is common ground for everyone, including your clients, that, in future, manufacturing cracks cannot be tolerated in a highly stressed area.

Sir Hartley: That is, of course, an important point, but there are always people who like to search around to see if there are any scapegoats.

Sir Hartley quoted an answer by Dr. Walker that a manufacturing crack was less likely to propagate than a fatigue crack. " If a manufacturing crack is properly drilled out it is no more of a stress raiser than a rivet hole."

Sir Hartley said: " My submission is that the processes of manufacture, even if they had set up an incipient crack, could not have set up an incipient crack in the place in the starboard rear corner of the ADF hatch where fatigue alone is known to have originated.

" Whatever view your Lordship thinks fit to express about cracks—and I am certainly not going to justify them for a moment; we never have—I would like the court to find in the most unequivocal terms that so far as these disasters are concerned there is not a shred of evidence to say that cracks had anything to do with the accidents.

" There has been so much publicity attaching to this matter that in my submission it would be right that there should be a clear finding on that matter, and the evidence is really all one way with regard to it.

NO CONCESSIONS FOR CRACKS

" I say on behalf of Messrs. de Havillands that in a structure which is subject, as we now know the high-pressure fuselage to be, to the risk of high-level fatigue, it is most undesirable to have cracks, and Messrs. de Havilland would not now grant a concession for cracks. They will exercise the utmost vigilance, both in their process of manufacture and in their inspections, to ensure that no cracks are allowed. I want to say that quite clearly and categorically.

" If an aircraft was otherwise safe," he continued, " an accidental crack would not, and ought not to, jeopardise it and it was right that the public should be reassured about that. A manufacturing crack or an accidental crack was usually much less serious than a fatigue crack."

Sir Hartley Shawcross declared: " The real problem which confronts the aircraft industry is the problem of fatigue. The real question is how fatigue is to be avoided—not how the cracks are to be avoided."

Summing up the position on the cracks, Sir Hartley Shawcross made the following points: (1) The cracks had nothing to do with the actual cause of the accident. The evidence so far as Comet Yoke Peter is concerned is really conclusive. (2) For the future we shall seek to construct this aircraft in a way which will ensure that no crack of the kind we have discussed could jeopardise the safety of the aircraft. (3) We shall do that by using thicker-gauge materials in the skin and, by such re-designing as may be indicated, to give a general stress level at which this kind of accidental stress-raiser would not raise the stress to a dangerous level. (4) We shall exercise every possible precaution in manufacture and use to guard against cracks but if, in the life of an aircraft, cracks do occur they will be dealt with on their merits, the principle being that any repair scheme which is sanctioned will leave the aircraft at least as strong as it was before the crack appeared.

Discussing the disaster to Yoke Yoke, Sir Hartley said there was the same family resemblance between the two accidents. There was the same catastrophic, or apparently catastrophic, disaster without time for any distress signal to be sent out. It occurred at about the same points where the aircraft was reaching the top of its climb. There was the same medical evidence; and there was the fact that within the apparently wide range of scatter it was recognised that Yoke Yoke was in danger of a fatigue collapse.

Sir Hartley Shawcross said there had been some suggestion that the Comets should have gone to Boscombe Down for testing and quoted a newspaper headline " Boscome Down By-passed."

He said: " There is no foundation at all for the suggestion made in one newspaper that because Boscombe Down was by-passed the Comets were delivered ahead of contract dates. Boscombe Down was not by-passed. The Comets were delivered ahead of dates, but that was because there was more time to do what had been necessary at that time and there was no pressure on the production side. It is not normal for a civil aircraft to go to Boscombe Down."

Sir Hartley said that the aircraft went through three different testings by pilots. " We would submit that it would not really be useful or practicable, to introduce a fourth set of masters."

It would be highly unwise to do anything which would diminish the Air Registration Board's responsibility and authority by introducing another organisation for testing.

Sir Hartley continued, " The probable cause we know of, in actual experience in Yoke Peter, is fatigue of the pressure cabin, and in our submission everything leads to the same conclusion of that being the cause of the disaster, unhappily, of Yoke Yoke."

The inquiry adjourned until Tuesday when Sir Hartley Shawcross continued his final address to the Court. He said it might definitely be stated that, subject to the conclusions and recommendations which the court might make, " Comet aircraft can and will again fly, this time with the assurance of this unique background and testing which has taken place."

He went on " These disasters have of course been a grievous setback not only to de Havilland but to the whole aviation industry.

" This country has no reason to be ashamed of what has come out in the course of this inquiry. In no country in the world would there have been so prompt, so public, and so thorough an inquiry into the reasons for what has happened.

" As the result of it all, much has been discovered of the greatest value to aviation as a whole. There is little for which de Havilland have cause to be ashamed.

" The problems of this inquiry are by no means the problems of Messrs. de Havilland alone. They are the problems which confront the whole of the modern aircraft industry in every country in the world. This is certain, and Britain can perhaps take pride in it. We hope the Comet aircraft, before too long, will again be in the air enabling British aviation to take its part in leading the world. It will go up to the skies this time with a quite unique background of investigation and research."

PROPOSED MODIFICATIONS

Sir Hartley then read to the court the official statement from the de Havilland company. The statement read: " Now that the danger of high-level fatigue in pressure cabins has been generally appreciated, de Havilland will take adequate measures to deal with this problem. Naturally these measures will be taken in full consultation with the A.R.B. To this end we propose to use thicker-gauge materials in the pressure-cabin area and to strengthen and redesign windows and cut-outs, and so lower the general stress to a level at which local stress concentrations either at rivets and boltholes, or such as may occur by reason of cracks caused accidentally during manufacture or subsequently, will not constitute a danger.

" In addition, de Havilland are already engaged on an extensive programme of detailed testing in order to establish a design technique which will minimise the effect of such local stress raisers as are necessarily inherent in the design. Further, de Havilland will carry out repeated loading tests on the lines indicated by Mr. Bishop.

" Every possible precaution will be taken by the use of appropriate design and manufacturing techniques and by stringent inspection procedure further to minimise the possibility of cracks occurring in manufacture. If a crack does occur at any time either in manufacture or subsequently during the life of an aircraft, no repair scheme for such a crack will be sanctioned by de Havilland unless it ensures that after it has been carried out the part of the aircraft concerned will be as strong and will have as long a fatigue life as it would have done had there been no crack.

" De Havilland are re-designing those parts of the wing structure which have been shown to be prone to fatigue in order to reduce the stress level. The measures to be taken will probably include an increase in the thickness of certain parts of the bottom skin reinforcing the area aft of the wheel well.

" Modifications have been devised which it is believed will prevent the venting of fuel during take-off and climb. These consist of modification 755 and modification 1404 (the syphon break). In addition, the vent exit will be taken into the jettison pipe so as to ensure that any fuel which may be vented will be discharged clear of the aircraft.

" De Havilland recognise the desirability of removing the possibility of damage from this source and are devising a method of doing this. As Mr. Wilkins stated, it is not possible to particularise at the present what the modification will be, but de Havilland have no doubt that the risk of damage can be removed. In addition, de Havilland will advise operators to incorporate a flow meter into the refuelling unit.

" De Havilland are considering a modification of the breakout force to suit the convenience and comfort of the pilot. They are investigating the possibility of considerably reducing the breakout force below the present figure of 18 to 20 lb. A reduced breakout force has already been incorporated in the design of the Comet 3.

NON-INFLAMMABLE HYDRAULIC FLUID

" De Havilland have carried out exhaustive investigations into the possibility of using non-inflammable hydraulic fluid. We shall continue to carry out further investigations and we hope that high priority will be given to the development of these fluids to make them suitable for use in modern commercial aircraft.

" De Havilland have reduced jet buffet on the underside of the fuselage by slightly altering the angle of the jet engines in Comets 2 and 3. The increase in the thickness of the fuselage skin will also serve to minimise the risk of damage from this source. Attention will be given to reinforcement of areas which are susceptible to damage from loading of passengers and freight."

Sir Hartley discussed whether the pressure-tank tests should be conducted by the firms themselves in tanks they constructed at their own factories or whether they should be conducted at Farnborough. The de Havilland company would certainly suggest that it would be a serious brake on the industry if all the tests had to be done in one particular Government centre. The company thought that wherever the tests were done they should be carried out to a standard laid down by the Air Registration Board.

Mentioning the modifications the firm proposed to make regarding the Comet 2 and 3, Sir Hartley said it was doubtful whether it would be practicable or expedient to carry out the modifications on the Mark 1 model to enable it to return to air-line service.

Mr. E. J. Rimmer, Q.C., representing British Overseas Airways Corporation and South African Airways, said " It is the magnificent work done at the Royal Aircraft Establishment by Sir Arnold Hall and his colleagues and the fact that this matter has been brought before your Lordship and his eminent assessors that has renewed our hope and belief that out of these disasters so much has been learned that under your findings, and the steps that are going to be taken, the jet-aircraft transport services may be resumed with complete assurance, so far as any known factor is concerned, of safety to the passengers and crew."

The inquiry was adjourned until Wednesday.

CERTIFICATE OF AIRWORTHINESS

When Mr. L. G. Scarman, representing the Air Registration Board, referred in his final address to tests to ascertain the cause of the accident, he said, " Although one cannot and must not rule out fatigue as being the cause of the disruption of this pressure cabin, it is clearly possible one may still have a scientific doubt as to whether it was proved. I am not instructed by the Air Registration Board that the Farnborough-report view is wrong. It may very well be that your Lordship, considering all the evidence, thinks that on the whole the Farnborough view is more probable than any other."

Mr. Scarman said a possible ground for criticism of the Air Registration Board was: Why did they not withdraw the certificate of airworthiness of the Comet when they were becoming increasingly aware of fatigue.?

" We know from the evidence that at the beginning of 1953 the fatigue problem in regard to wings,

particularly, and also pressure cabins, was becoming more intensively studied. That being so, the question arises whether the A.R.B. should either have limited the life of the Comet, or withdrawn the certificate of airworthiness, because of the new facts that were coming to light."

He continued: "It could be said that surely with this new knowledge available they should have determined, or set a limit to, the flying hours of the Comet. The answer is that the certificate of airworthiness is for a year only. In my submission, it was quite reasonable in view of all the thinking of the A.R.B., and of the data available to them, to say that in 1953 there was no indication at all that the Comet would be then approaching the end of its safe life during the current year of flying.

"While the A.R.B. in their discretion, and in the right exercise of that discretion, were taking no steps to stop the Comet flying in 1953, notwithstanding advances that were being made on this subject, the A.R.B. themselves were at that time energetically pursuing these studies and encouraging others to embark upon them and to research in them."

Referring to manufacturing cracks, Mr. Scarman said: "My submission is that these manufacturing cracks had nothing to do with the Elba accident nor, indeed, the Naples accident."

Mr. Scarman submitted that no action or default of the Air Registration Board caused, or contributed to the cause of, these accidents. The aircraft were airworthy at the time of the accidents, so far as could then reasonably have been ascertained.

In his final address, Sir Lionel Heald, Q.C., who appeared for the Crown, said: "Altogether I hope and believe that we can justifiably accept the view suggested by Sir Hartley Shawcross that this inquiry has measured up to a standard of which there is no reason to feel ashamed."

The inquiry would not be inconclusive because two quite separate things entered into combination: the salvage operation carried out by the Royal Navy and the tank test carried out by the Royal Aircraft Establishment at Farnborough.

"If you recall the occasion when the two pressure cabins emerged from under the dust sheets one can see that we have there presented a most striking demonstration, which I think could properly be described as a classic example in the field of circumstantial evidence."

Winding up the inquiry, Lord Cohen said, "I will, with the assistance of my assessors, prepare the Report as soon as I reasonably can." The Report will be made to the Ministry of Transport and Civil Aviation.

* * *

LIGHT-ALLOY SLEDGES

A sledge built in the shape of a punt and made entirely from aluminium alloy was tested under actual working conditions, shown in the accompanying illustration, by the British (Sherborne-Cambridge) Spitsbergen Expedition, 1954. The expedition returned to this country a few weeks ago after a three-month visit to the Arctic.

The idea of using aluminium sledges originated with the organiser of the expedition, Dr. G. T. Wright, M.A., of Marlborough College, and after discussions rough sketches of the sledges were made. No detail drawings were prepared, and the sledges were hand-made by Elms Metals, Limited, using various aluminium alloys supplied by James Booth and Company, Limited.

Three sledges were constructed, one 12 ft. long and two 8 ft. long, and the main shells were each formed from a single sheet of 16-s.w.g. M.G.5 alloy, with edge stiffeners of $\frac{7}{8}$ in. by 18 s.w.g. M.G.5 tube and tying hooks cut from M.G.5 plate. Both stiffeners and hooks were welded to the main shells. The three sledges were each 2 ft. wide and 8 in. deep, and ran on runners, 2 in. high and $2\frac{1}{2}$ in. deep, riveted to the main shell. The runners were constructed from Duralumin "H" extruded top-hat section.

A report on these sledges says that they moved easily over pure ice and in the higher snowfields of the glaciers, and that although the largest sledge carried a load of 500 lb. and each of the smaller ones 300 lb., the runners rarely sank into the snow more than $\frac{1}{2}$ in. The report suggests that for soft snow it may be advisable to fit aluminium-alloy ski-runners on 6-in. pillars below the main shell.

One of the difficulties associated with camping in the Arctic or Antarctic is to obtain water, because melting snow or ice is a long process and expensive in paraffin. It occurred to the expedition that the "boat" shape of the new sledges might make them suitable as water reservoirs. Each time the expedition camped in one place for any length of time the sledges were filled with snow which the sun soon melted, through direct insolation and radiation from the aluminium.

Punt-shaped sledges of aluminium alloy have been tested by the British (Sherborne-Cambridge) Spitsbergen Expedition.

* * *

TRAFFIC CONTROL IN OXFORD STREET

Electronic Master Controller

The Autoflex vehicle-actuated progressive system of traffic control has been installed by the Siemens and General Electric Railway Signal Company, Limited, North Wembley, in the $1\frac{1}{4}$ miles of Oxford-street, London, between Marble Arch and St. Giles Circus; and was formally inaugurated by the Minister of Transport (the Rt. Hon. J. Boyd-Carpenter) on Monday, November 29. It replaces the fixed-time progressive system installed in 1930-31.

The progressive system which is employed by both the old and new methods of control is designed so that vehicles travelling along Oxford-street at a certain speed—known as the "progressive speed"—would in general find each set of signals at green on reaching them. In the old system, however, any change made in the progressive speed, due, for example, to increased traffic density, would alter the proportion of main to side-road traffic; since the proportion is likely to remain constant, this was undesirable. Moreover, the old system had the serious drawback that switching of the right of way from one road to another took place in rotation at regular intervals, whether vehicles were on the second road or not.

In the Autoflex system an electronic master controller provides a master cycle time, which is transmitted to local controllers at the 16 signalled crossings on the route. These controllers work in conjunction with vehicle-actuated detectors and normally transfer the right of way from the main road to the side road at a pre-determined instant. This transfer does not, however, take place unless a "demand" for right of way has been made from a side road; and a re-transfer occurs in advance of the "pattern" set up by the master controller if the side-road traffic does not warrant its continuance. On the other hand, the more important side-road intersections may enjoy a continuance of the right of way after or before the times determined by the pattern. All these demand adjustments, however, which take place within the limits imposed by the progressive pattern; no traffic proceeding along Oxford-street at progressive speed, for example, would be delayed by demand from a side street.

TRAFFIC DENSITY ASSESSOR

Traffic in Oxford-street presents special problems, since it is very heavy during the week-day business hours and comparatively light in the late evenings and at week-ends. In addition, pedestrians and buses often prevent the full use of the rights of way; and the irregularity with which the side roads are spaced renders the planning of a progressive pattern difficult. Temporary congestion due to vehicle mishaps cannot be altogether avoided.

The difference between periods of heavy and light traffic is dealt with by a density assessor, or integrator, at Oxford Circus. This varies the cycle time of the master controller and hence that of the crossing controllers in accordance with the flow of traffic, and changes the progressive pattern to suit high or low densities. To do this, impulses from the vehicle detectors are summated by an electronic circuit, which passes a count at a pre-determined level to a step-by-step switch. After five minutes the result is compared with that of one previously stored and, if it differs from this by more than a fixed amount, it is stored in turn and utilised to bring about the changes at the selected levels. If the difference is less than the fixed amount no change occurs. Alternatively, the integrator may be replaced by a time switch to guard against the former being unable to count accurately in a traffic jam.

PEDESTRIAN INTERFERENCE

Pedestrian interference and accidents are dealt with by introducing artificial demands in favour of the main and, ultimately, of the side roads, so that a right of way is granted even if movement over the vehicle detectors is prevented. To increase the speed of progression during periods of light traffic the cycle time set by the master controller is varied.

Arrangements have been made so that the existing Autoflex progressive installation in Wigmore-street/Mortimer-street and the Electromatic installation in Regent-street will follow the timing of the Oxford-street master controller. This controller is therefore of great importance, and for that reason its impulse generating equipment is provided in duplicate, the stand-by mechanism being switched in automatically if a failure occurs to the working unit. The vehicle detectors employed are of the standard tube type* and the signal heads are fitted with a prismatic lens and secondary reflector.

* See ENGINEERING, vol. 168, page 686 (1949).

POLLUTION OF THE AIR

GOVERNMENT COMMITTEE WANT PLANT DESIGN IMPROVED

The report of the Committee which was appointed in July, 1953, under the chairmanship of Sir Hugh Beaver, "to examine the nature, causes and effects of air pollution and the efficacy of present preventive measures; to consider what further preventive measures are practicable; and to make recommendations," was published by H.M. Stationery Office last week (Cmd. 9322, price 2*s.* 6*d.*).

The Committee state emphatically that air pollution on the scale present in this country to-day is a social and economic evil which should no longer be tolerated; and that it needs to be combated with the same conviction and energy as were applied 100 years ago to secure pure water. Recommendations are made, the object of which is to reduce the total smoke in all heavily populated areas by 80 per cent. by the end of ten to fifteen years. This would mean a degree of freedom from air pollution which many parts of the country have not known for more than a century. As it is, pollution is costing the nation about £250 million per annum. In addition, between £25 million and £50 million represents the value of the fuel lost by incomplete combustion.

INDUSTRIAL SMOKE

Evidence confirms the previously expressed view that with a few exceptions no industrial chimney need normally emit more than a light haze of smoke, if the combustion arrangements are adequate and properly operated. It is, therefore, recommended that with some necessary exceptions the emission of "dark" smoke (that is, smoke of density equivalent to or greater than shade 2 on the Ringelmann Chart) should be prohibited by law. Before this is possible, however, extensive modernisation and improvements of the 40,000 or so hand-fired boilers in use will be necessary; and to enable these to be carried out it is proposed that the scope of the present Government loan scheme, whereby capital is available for approved fuel-saving projects, should be extended to include projects directed to the reduction of air pollution.

It is also urged that the National Industrial Fuel Efficiency Service's plan for educating firemen should be extended and that trained and efficient firemen should be financially rewarded. As some form of smoke indicator is a useful check on the amount emitted it is further recommended that the British Standards Institution should prepare codes of practice, indicating the extent to which smoke can be reduced and the means of doing this, and that specifications for smoke indicators and guidance on their installation and use should be published.

GRIT AND DUST PROBLEMS

To regulate the emission of grit and dust from chimneys, independently of dark smoke, it is considered essential that the most efficient arrestors should be used on all furnaces which burn either pulverised fuel or solid fuel in any form in large quantities. It is, therefore, recommended that all industrial and trade furnaces which are fired by solid fuel should by statute be equipped to prevent the emission of grit or dust; that every new industrial installation which is designed to burn pulverised or solid fuel at a maximum rate of 10 tons per hour or more should be provided with grit-arresting appliances; and that regular measurements should be made of grit emission.

In the case of modern power stations, it is pointed out, the problem is accentuated by their size. This means that, even when the most efficient electrostatic precipitators are installed, some 10 tons of dust may be emitted daily. As, moreover, this plant may add as much as 10 per cent. to the cost of the boiler there is scope for less dusty methods of combustion. Such methods are in course of development and, if successful, will in time mitigate the nuisance. Many of the present complaints are directed at the older boilers which are equipped only with mechanical grit arrestors and have low chimneys. Although it would be uneconomic to modernise power stations the life of which is limited, it is nevertheless considered that there should be a definite date, say 1964, after which no power station should be allowed to operate with inadequate arresting appliances or with unduly low chimneys, except in emergency.

These provisions for the prohibition of dark smoke and grit and dust should not, it is recommended, apply to certain processes in the heavy chemical and allied industries, such as some metallurgical operations and the manufacture of cement. These processes are already controlled by the Alkali Acts and there is no serious criticism of the results. It is, however, proposed that these "scheduled processes" should be designated by Act of Parliament and that the appropriate Minister should have power to extend or curtail the list. It is suggested that the initial list should include metallurgical works, power stations, gas works, coke works, ceramic works and lime works.

SULPHUR POLLUTION

One of the most deleterious products of combustion is sulphur, which results in about 5¼ million tons of sulphur dioxide being discharged into the air every year. This quantity is unaffected by the efficiency of combustion. The obvious initial step in reducing pollution from this cause is to remove as much sulphur as possible from the coal at the pits. There is, however, a limit to what can be done in this way. Technically most of the sulphur can be removed from fuel oil, but the cost is at present too great for it to be undertaken commercially.

It would be satisfactory if some material could be added to the coal before combustion so as to retain the sulphur in the ashes. No practical success has so far attended efforts to do this, but we would like to see further research carried out in this direction.

The method of washing sulphur dioxide from the flue gases on the way to the chimney is at present only practicable in very large installations. About 80 per cent. of the sulphur dioxide is removed in this way at the coal-fired power station at Battersea and 95 per cent. at the oil-fired station at Bankside. Both processes, however, require vast quantities of water, and it would not be possible to use them to any greater extent on the Thames. In the process employed at Fulham for some years over 97 per cent. of the sulphur dioxide was removed, but the present cost of operation would be about 10*s.* per ton of coal burnt, compared with 8*s.* per ton at Battersea. A substantially cheaper process which produces sulphate of ammonia as the end product is now on the point of large-scale trials by the British Electricity Authority. The Committee feel that this method promises good results and that there should have been less hesitation in putting it into practical operation.

GAS WASHING DESIRABLE

The standard practice in modern power stations is to discharge the gases unwashed through chimneys 300 ft. or more high. It is claimed that these hot gases have a buoyancy which carries them high into the atmosphere where they are diluted and dispersed so as to be relatively innocuous by the time they diffuse to ground level. The objection urged to washing is that it lowers the temperature of the gases and reduces their buoyancy so that, although a washed gas contains much less sulphur dioxide, it reaches ground level more quickly.

Nevertheless, the Committee have reached the conclusion that gas washing is desirable provided that the process removes not less than 90 per cent. of the sulphur dioxide. If this proportion is reached it is unlikely that pollution in the immediate vicinity would be aggravated by cooling the gas. The cost of gas washing, even if it amounts to 0·06*d.* to 0·07*d.* per kilowatt-hour supplied, might well be justified by the advantages of a cleaner atmosphere and other benefits. It is therefore considered that the most efficient methods of removing sulphur dioxide from flue gases should be adopted at power stations in future, except when they are so sited as to avoid polluting densely populated areas. Gas washing should not, however, be taken as a justification for lowering the chimneys.

The complete removal of sulphur dioxide from power station gases would leave more than three-quarters of the sulphur problems unsolved. No methods exist whereby the discharge of the greater part of the industrial sulphur from industrial and domestic chimneys can be prevented. This is an important issue which requires further attention and is one of the matters which the Committee recommend for intensive research.

RAILWAY SMOKE

Railway locomotives are responsible for over one-seventh of all the smoke discharged to the atmosphere. There can be no doubt that the only complete answer is the replacement of coal-fired locomotives by electric, Diesel or other smokeless methods of traction. The British Transport Commission's programme of electrification should be accelerated; so should the change-over to Diesel engines. We consider that there should be no coal-fired locomotives used for shunting, either on the railways or at industrial works, in any "black" area after 1960.

We have made inquiries into the possibility of substituting Diesel or electric for steam traction while trains are entering and leaving the black areas, but we understand that the operating difficulties involved are such as to make this impracticable.

Pending the extended use of alternative methods of traction, further steps should be taken to reduce smoke from steam locomotives. We would draw special attention to the use of over-fire jets, which we understand are now used with good results in the U.S.A.

MOTOR VEHICLES

The contribution of motor-vehicle exhaust gases is still relatively small, but it can reach considerable proportions locally in areas of heavy traffic congestion when the movement of air is restricted. At our suggestion the Fuel Research Station are now making a study of the extent of pollution by these exhaust gases in London streets under different weather conditions.

More attention must be given to the proper maintenance and driving of Diesel-engine vehicles and the necessary servicing facilities must be provided. It would be useful if means could be found whereby a driver could be made aware that he is emitting smoke. We would not agree that even at starting such smoke should be tolerated, but to prevent it will require research into Diesel-engine design. The present law on the subject is explicit, and in our view adequate. We cannot find, however, that the law is, in fact, enforced.

DOMESTIC SMOKE

Nearly half of all the smoke in the air comes from domestic chimneys. There would be little justification for requiring industry and commerce to take all possible measures to prevent smoke, often at considerable cost, if the problem of domestic smoke were not also tackled. (The report here reviews the various factors involved; it remarks that district heating schemes, though technically efficient and smokeless, are only practicable in special conditions and, in the absence of a simple heat meter, generally uneconomic; and it concludes that the replacement of house coal throughout the black areas by

coke and other smokeless means of heating is practicable).

PERMITTED SMOKE

The report recommends the strengthening of legislation in various ways. A "Clean Air Act" is proposed which would prohibit the emission of dark smoke from any chimney after three years from the publication of the report. It will be necessary to make allowance for short discharges of dark smoke which are unavoidable at certain times, for example, during soot-blowing and raking of fires. A total upper limit of six minutes of dark smoke in any period of four hours, with no single burst lasting more than three minutes, is recommended.

To regulate grit and dust from chimneys the Committee recommend that, with certain exceptions, (1) the owners and occupiers of all industrial or trade premises in which furnaces are fired by solid fuel should be under a statutory duty to take all reasonably practicable steps to prevent the emission of grit or dust therefrom; (2) every new industrial installation which is designed to burn pulversied fuel, or solid fuel in any form at a maximum rate of 10 tons an hour or more, should be provided with effective grit-arresting plant . . . ; (3) in the case of any such installation, new or existing, it should be the duty of the owner or occupier of the premises, if so required by the local authority, to make regular measurements of grit emission . . . .

We recommend that a "Clean Air Council" should be appointed to co-ordinate all aspects of the work in the future.

FURTHER RESEARCH REQUIRED

Further research is recommended on:—

(1) More frequent and intensified measurements of pollution in the London area and in three or four other specified areas which are susceptible to severe "smog."

(2) The development of automatic recording instruments for measuring pollution by smoke, sulphur compounds, carbon monoxide, and other pollutants.

(3) The intensification of research directed towards the possibilities of: reduction of the amount of sulphur in fuel before use; prevention of the release of the sulphur in the fuel into chimney gases; removal of sulphur from the chimney gases before discharge into the air; and providing more information on the dispersion of sulphur compounds in flue gases after discharge from chimneys of various heights and in all atmospheric conditions, and the ultimate fate of the sulphur compounds.

(4) The physiological effects of air pollution on health . . . .

(5) The effects on the dispersal of pollution of chimney height, chimney design, and the position of chimneys in relation to surrounding buildings, hills, etc.

(6) The development of cheaper and more efficient dust-arresting equipment for both large and small plants, particularly for dealing with the finest particles of dust.

(7) The development of techniques and instruments for monitoring grit and dust emissions.

(8) The development of improved techniques for the prevention of pollution from the special processes for which the Alkali Inspectorate is responsible, including the "scheduled processes."

(9) The prevention of harmful emissions from motor-vehicle exhausts, particularly of Diesel engines, by the development of improved designs of engine and fuel induction, and of catalytic and other devices for effecting the more complete oxidation of the gases after leaving the engine; and the development of monitoring devices.

(10) The prevention of combustion in colliery spoilbanks . . . .

(11) The production of solid smokeless fuels from other types of coal than those now used in gas and coke manufacture.

(12) The development of more efficient and economical domestic appliances, including if possible appliances capable of burning bituminous coal without smoke, and better methods of installation.

(*Editorial comment in Weekly Survey*)

CONTRACTS

Turbo-Alternator Plant for Paper Mills. The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, have received a contract from Empire Paper Mills Ltd. (an organisation within the Reed Paper Group) for a 4,500-kW double pass-out geared turbo-alternator, complete with condenser and feed heater, which will form part of a scheme for modernising the power supplies of the Greenhithe paper mill. At present, the mill operates on a 40-cycle supply. It is proposed to change this to 50-cycles and the new set will generate three-phase current at 50 cycles, 3,000 volts. The turbine will be supplied with steam at 600 lb. per sq. in., and 800 deg. F., from a new oil-fired boiler. The condenser, single-stage feed heater and the 300,000-lb. per hour de-aerator are being supplied by Hick, Hargreaves & Co. Ltd.

Aircraft. A second contract for Viscount aircraft has been received from Hunting-Clan Air Transport Ltd., by Vickers-Armstrongs Ltd., Vickers House, Broadway, London, S.W.1. The new order is for two Viscount 700D machines. This brings the number of Viscounts ordered by Messrs. Hunting-Clan to five, the first of which are due for delivery next spring. Orders for 157 Viscount aircraft have now been received to date.

Belt Conveyors for Flood Protection. A contract for belt conveyors has been awarded by Sir Robert McAlpine & Sons (Midlands) Ltd., to Richard Sutcliffe Limited, Horbury, Wakefield. The conveyors and other equipment are for use on the Great Ouse flood protection scheme, near King's Lynn, Norfolk. A relief channel, 200 ft. wide and approximately 11 miles long, is to be made, and the excavated earth formed into a bank 20 ft. high on each side. The project, which is estimated to take five years to complete, will require the removal of 12,000,000 cub. yd. of soil, stones, clay, silt and sand. The conveying scheme is designed to operate at a rate of 600 tons an hour.

Boiler Plant. A contract for the supply, delivery and erection of boiler plant, boiler-house steelwork, a heating system, a steam-distribution system and compressed-air mains, at the Temple Mills Wagon Works of the Eastern Region of British Railways, has been placed with the Brightside Foundry and Engineering Co. Ltd., G.P.O. Box 118, Sheffield 1.

Telephone Equipment. A contract valued at 2½ million dols. has been awarded to the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2. It is for extensions to the telephone system of Haiti, the independent republic in the Caribbean Sea. Besides extensions to telephone exchanges in Port-au-Prince, the capital, and other towns, as a result of which some 3,300 new subscribers will be connected, the contract provides for the building of 500 miles of open-wire trunk-line routes. The associated carrier telephony equipment, at terminal stations and at points along the route, is also to be supplied. Where mountainous terrain makes the construction of lines uneconomical, very-high-frequency trunk radio is to be incorporated. A large portion of the contract consists of street-cable and pole routes, the material for which is to be supplied by Pirelli-General Cable Works Ltd., an associate company of the G.E.C. Shipments will start in three months' time and will continue for a further 18 months. The work of installation and erection, which will be carried out by local labour under the direction of G.E.C. engineers, is expected to take three years to complete.

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OBITUARY

We regret to record the deaths of:

Mr. Arthur James Lamb, at Beckenham, Kent, on November 20, at the age of 54. An experienced engineer, Mr. Lamb had been on the staff of the Paterson Engineering Co. Ltd., manufacturers of water-purification and filtration plant, Windsor House, Kingsway, London, W.C.2, for the past 25 years. For much of this time he served as manager of the firm's industrial water-treatment plant department, a position he was occupying at the time of his death.

Mr. Reginald Thomas Orme, at Derby, on November 21, at the age of 84. Mr. Orme was chairman and managing director of T. D. Robinson and Co. Ltd., manufacturers of rivets, Derby, and had been head of the firm for upwards of 40 years.

Letters to the Editor

PAYING OTHERS TO DO RESEARCH

Sir, It might be inferred from the Weekly Survey note "Paying others to do Research," in your issue of November 12, that research associations do not undertake sponsored research.

While this may be generally correct, it is not so in the case of the British Iron and Steel Research Association. Our effort directed in this way is, of course, relatively small in relation to that expended on co-operative research, but is nevertheless not insignificant. Such work is undertaken where (1) the Association has the requisite background knowledge and experience with which to tackle an investigation with a reasonable promise of a successful result; (2) the Association possesses special equipment which may be utilised to advantage; (3) the work undertaken will in a general sense add to the store of knowledge and experience of the Association, and be of value to the Association and the industry as well as to the sponsoring organisation, even though details may have to be kept confidential; (4) the interests of the steel industry are not prejudiced.

It is considered that confidential sponsored research is especially suitable for plant makers in the development of their own equipment when it would indirectly assist the steel industry.

Yours faithfully,

R. W. Berry,
Technical Secretary,
Plant Engineering Division.

The British Iron and Steel Research Association,
140 Battersea Park-road,
London, S.W.11.
November 24, 1954.

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PERSONAL

The composition of a trade mission which is to visit Egypt, the Sudan and Ethiopia next year has been announced in the House of Commons. The leader will be Sir Edward Benthall, K.C.S.I., and the deputy leader, and leader in Ethiopia, Mr. G. C. R. Eley, C.B.E. The members will comprise: Mr. A. W. Berry, M.I.Mech.E., M.I.E.E., Mr. A. E. J. Gawler, Mr. Maurice Laing, Mr. T. A. L. Paton, B.Sc. (Eng.), M.I.C.E., Mr. J. F. Perry, A.M.I.E.E., Mr. G. Phillips, Colonel R. E. M. Pratt, O.B.E., Mr. P. G. G. Salkeld, C.B.E., and Mr. J. C. Tremayne.

Sir Rupert De la Bère, Bt., K.C.V.O., M.P., the "Coronation" Lord Mayor of London, has been appointed the first vice-president of the Institute of General Managers, 86 Eccleston-square, London, S.W.1.

Dr. H. F. Willis has been appointed chief of the Royal Naval Scientific Service, in succession to Mr. W. R. J. Cook, C.B., who has joined the staff of the Atomic Energy Authority.

Rear-Admiral W. T. Couchman, C.B., C.V.O., D.S.O., O.B.E., has been appointed to succeed Vice-Admiral C. John, C.B., as Deputy Controller of Aircraft, Ministry of Supply, in March, 1955.

Mr. R. A. Harding, who, as stated on page 550 of our issue of October 29, has been appointed managing director of Macrome Ltd., has now been made managing director of Hallmac Tools Ltd., Aldersley, Wolverhampton.

Mr. E. A. Watson has retired from the board of directors of Ruston-Bucyrus Ltd., Excavator Works, Lincoln, and Mr. W. L. Litle, President of the Bucyrus-Erie Co., South Milwaukee, Wisconsin, U.S.A., has been elected a director in his place.

High Duty Alloys Ltd., Slough, Buckinghamshire, announce that Mr. J. A. Wellings has been appointed director and vice-president of Canadian Steel Improvement Ltd., Etobicoke, Ontario, Canada. This firm and High Duty Alloys Ltd., are associated through the Hawker Siddeley Group.

Dr. L. F. C. Northcott, F.R.I.C., F.I.M., has been promoted to the position of deputy chief scientific officer, Ministry of Supply, and appointed senior superintendent of applied research at the Armament Research Establishment, Fort Halstead.

Mr. G. W. Wells and Mr. P. F. Benton Jones have been appointed to the board of the United

Steel Companies, Ltd., 17 Westbourne-road, Sheffield 10.

DR. C. L. M. COTTRELL has been awarded the 1954 Sir William J. Larke Medal of the Institute of Welding for his paper, "Hydrogen-Barrier to Welding Progress?"

MR. T. W. BALLARD, works manager of Tyer & Co. Ltd., railway-signalling engineers, Dalston, London, E.8, has retired after 53 years with the company. He has held the position of works manager since 1925.

MR. P. S. FIRMIN, A.M.I.E.E., has been appointed works director to Waymouth Gauge and Instruments Ltd., Godalming, Surrey, a subsidiary company of Smiths Aircraft Instruments Ltd.

The Metropolitan Vickers Electrical Co. Ltd., Trafford Park, Manchester 17, announce that MR. J. V. BIGG, M.A., A.M.I.Mech.E., has been appointed assistant chief engineer, condenser engineering department, MR. J. A. WALKER, Assoc.M.C.T., M.I.E.E., assistant manager, Sheffield office, and MR. K. GREENWOOD, B.Sc. (Eng.), district engineer, erection department, Glasgow.

Further to the announcement, on page 684 of our issue of November 26, that MR. H. R. MOORE, and MR. H. HEATH had been elected directors of Coventry Radiator and Presswork Holdings Ltd., we now learn that they have also been elected directors of Coventry Radiator and Presswork Co. Ltd., together with MR. J. G. DAVIES and MR. E. J. B. CHARE. MR. L. H. JACKSON is remaining in a consultative capacity.

MR. H. G. MEADS has been appointed a director of Hoover Ltd., Perivale, Greenford, Middlesex, and made comptroller of the company's financial and administrative services. He has relinquished his office of secretary to which MR. H. D. VIGERS, hitherto assistant secretary, has now been appointed.

MR. LAWRENCE HALPIN and MR. F. ARNOLD HURST, A.C.A., have joined the board of directors of Low Moor Alloy Steelworks Ltd., Low Moor, Bradford.

MR. D. A. R. CLARK, M.Sc.Tech., Assoc.M.C.T., M.I.Mech.E., Principal of Constantine Technical College, Middlesbrough, for the past seven years, has been appointed Principal of Nottingham and District Technical College and takes up his new post next September.

MR. H. H. SHEPHERD, F.I.M., F.R.S.A., metallurgical consultant and until recently metallurgical projects officer to the New South Wales branch of the Division of Industrial Development of the Commonwealth Department of National Development, has returned to Britain after spending several years in Australia. His temporary address is c/o Barclays Bank Ltd., Market-place, Spalding, Lincolnshire.

MR. K. M. SCOTT, A.M.I.C.E., has been appointed sales manager of Francis Morton & Co., Ltd., as from November 15. Following the forthcoming retirement of MR. T. C. GRISENTHWAITE, B.Sc., M.I.C.E., M.I.Struct.E., special director and London manager, on December 31, on account of ill health, Mr. Scott will operate from the company's London office, at 68-69 Avenue Chambers, 4 Vernon-place, Southampton-row, W.C.1.

MR. A. E. BOOKER has been appointed sales engineer of Transformers (Watford) Ltd., Sandown-road, Watford, Hertfordshire. He has been production manager of the firm since 1948.

MR. P. J. LOVEGROVE has been appointed sales manager of Measuring Instruments (Pullin) Ltd., Electrin Works, Winchester-street, Acton, London, W.3.

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BUSINESS CHANGES

To handle increasing sales of their rotary-shaft mechanical seals, FLEXIBOX LTD., Nash-road, Trafford Park, Manchester 17, are forming an associated company in France: FLEXIBOX S.A.R.L., with offices and works at 40 Avenue de Verdun, Croissy-sur-Seine. This follows the setting up, earlier this year, of an associated company in Germany: FLEXIBOX G.M.B.H., Zeil 68, Frankfurt-am-Main.

SILENTBLOC LTD. are vacating their premises in Ladbroke-road, Notting Hill Gate, London, W.11, for a new factory at Crawley. After December 20, all correspondence should be addressed to Manor Royal, Crawley, Sursex.

FRENCH RAILWAYS LTD. announce that their telephone numbers have been changed to: HYDe Park 9731-4, and that their publicity department will be shortly transferred from Victoria Station to 179 Piccadilly.

CRACKS IN FATIGUE SPECIMENS

Investigation by Electrolytic Polishing

At the Bristol University recently, some extremely interesting investigations have been carried out on the development of fatigue cracks in pure-copper laboratory specimens subjected to repeated push-pull loading at 1,000 cycles per second. It is possible that these studies, when continued further, may throw valuable light on the mechanism of fatigue failure.

An account of these experiments was given at the Royal Aeronautical Society on Thursday, November 25, in a lecture entitled "The Development and Investigation of Fatigue Cracks," by Dr. N. Thompson. A summary of the lecture (which will be printed in full in a forthcoming issue of the *Journal* of the Royal Aeronautical Society) has been prepared for us by the author and is given below.

He writes: A recent paper "The Growth of Fatigue Cracks," by Mr. A. K. Head (*Phil. Mag.*, vol. 44, September, 1953, page 925) has shown that it is possible to set up a theory of the propagation of a fatigue crack which is in agreement with the available data; his argument pre-supposes that it is justifiable to treat the material as a homogeneous isotropic solid. In the early stages, however, when the dimensions of the crack are comparable with the grain-size of the material, other factors must be dominant. It has been shown in numerous instances that a fatigue crack originates at some singularity—an inclusion, cavity, or grain boundary, for example—which gives rise to a stress concentration. But although this may determine where the crack starts, it throws no light on the mechanism of its origin.

It has been known for some time that in some instances the fatigue crack starts in a region of intense slip. This has been amply confirmed by recent work in the H. H. Wills Physical Laboratory of Bristol University on oxygen-free high-conductivity copper, both polycrystalline and in the form of single crystals. Using an electropolishing technique it has proved possible to demonstrate the presence of one or two incipient fatigue cracks before 50 per cent. of the normal fatigue life has expired. The beginnings of the same process can be detected after as little as 5 per cent. of the life and they are always to be found in an intense slip band. A considerable number of such sites can be found in the early stages of a fatigue test, but only a few develop into undeniable cracks before the largest of them leads to complete failure.

Such markings have been called "persistent slip bands" from the fact that they are still visible after—and possibly intensified by—an electropolishing treatment which removes the majority of the slip bands produced by the fatigue test. They are to be found on the surface only and not in the interior of either a polycrystal or a single crystal. They can be removed by a deep electropolish which takes off a layer of metal 10 to 20 microns thick. If this is done at intervals during a fatigue test, it is possible to prolong the life. In one case, such a treatment was given at intervals equal to 25 per cent. of the expected life. After nine runs, giving 2¼ times the normal life, the specimen surface was as good as new and showed no signs of even the early stages of failure. Annealing *in vacuo* for one hour at 600 deg. C. at intervals throughout a test, on the other hand, has no significant effect on either the fatigue life or the appearance of the persistent slip bands.

The evidence is consistent with the view that the persistent slip bands indicate the presence of something with the characteristic properties of a crack at as early as 5 per cent. of the fatigue life. But it cannot be claimed that such a result is definitely established. It was shown some years ago by Dr. H. J. Gough, for example, that the endurance can be increased by preventing the access of oxygen to the surface of the specimen during the test. This result has been confirmed by the present work. It has also been shown, by conducting the tests in an atmosphere of dry nitrogen, that the development of the persistent slip bands is retarded by the absence of oxygen. If the whole process is simply the slow growth of micro-cracks, the role of the oxygen needs to be determined.

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EXHIBITION OF X-RAY APPARATUS

An exhibition of X-ray apparatus, organised by the British X-ray industry on the occasion of the annual congress of the British Institute of Radiology, was held at the Royal Horticultural Hall, Vincent square, London, S.W.1, from Tuesday, November 23, to Friday, November 26. Most of the exhibits were illustrative of the progress that is being made in the use of this type of apparatus for medical purposes.

Solus-Schall, Limited, 18 New Cavendish-street, London, W.1, showed a complete range of non-destructive testing equipment. This included a 300-kV X-ray unit which has been designed for the investigation of specimens from light-alloy castings up to 4-in. steel sections. Its cathode generator, control box, tube stand and cable can be used as the basis of a 150-kV constant potential set with a rod anode or fine-focus tube. This tube emits a 360 deg. beam and is intended for inspecting circumferential welds in pipes, tubes and pressure vessels or for the simultaneous radiography of a number of castings arranged round it in a circle. An interesting accessory shown by the same firm was a small mains operated attachment, which has been designed to give a high degree of accuracy in centring an X-ray beam on the object to be radiographed and thus to overcome the difficulty of keeping a centring rod rigid over a long-focus film distance.

Marconi Instruments, Limited, St. Albans, were exhibiting an image amplifier, in which the normal fluorescent screen for displaying the radiogram is replaced by an electronic image-converter tube. This tube has a fluorescent surface upon which the X-rays passing through the patient impinge and excite a photo-electric plate. The electrons thus emitted are then accelerated by a high potential from an external source and are focused by a system of electronic lenses onto a screen 1 in. in diameter, so that a considerable increase in brilliance is obtained. This image is finally magnified to its natural size by an optical system and can be viewed in a mirror.

The equipment exhibited by General Radiological Limited, 15 Clipstone-street, London, W.1, included a shockproof and rayproof X-ray unit, which has been primarily designed for mobile purposes in a hospital. Its overall height has been reduced to 6 ft. by housing the spring counterpoise pulley in the base of the unit. In this way manœuvrability has been increased without reducing the range of movement. The peak voltage of the unit is 90 kV and the maximum tube current 90 milliamperes.

MEASUREMENT OF RADIOLOGICAL QUANTITIES

Instruments for measuring radiological quantities were a feature of the stand of the Baldwin Instrument Company, Limited, Dartford, Kent. They included a meter for indicating the dose of ionising radiations between 300 milli-röntgens and 1,000 röntgens and the dose rate between 30 milli-röntgens and 1,000 röntgens per minute. It consists essentially of a direct-current feedback amplifier, a high stabilised mains power pack and an interchangeable ionisation chamber with the necessary measuring scale.

The exhibits of Mullard, Limited, Shaftesbury-avenue, London, W.C.2, included a variety of diagnostic X-ray tubes, both of the stationary and rotating-anode patterns. Among the latter was the MRA type which can be used for taking moving X-ray pictures of such bodily functions as the beating of the heart.

BOOKS RECEIVED

Some of the books noticed in the Books Received column are selected for extended review in later issues of ENGINEERING.

Some Fundamentals of Petroleum Geology. By G. D. HOBSON. *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (18*s.*)

This book is concerned with the nature of oil accumulation, and with ideas on the origin of oil and its aggregation into a commercial oil pool. Reservoir pressure is discussed in some detail, and appendices describe the phenomenon of compaction in sediments and define certain important terms. Wherever possible, an attempt has been made to examine the various phenomena and hypotheses quantitatively as well as qualitatively.

Industry and the Graduate and **A Career for the Graduate in Industry.** F.B.I. Handbooks. *Federation of British Industries*, 21 *Tothill-street, London, S.W.*1. (2*s.* each.) (See Leader in this issue.)

Regulations and Syllabus for Whitworth Scholarships, 1955. *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*d.*)

The awards being offered are two Whitworth Senior Scholarships, five Whitworth Scholarships, and up to ten prizes to unsuccessful competitors for Scholarships whose work deserves recognition. Applications for admission to the competition must be received, on the prescribed form, not later than January 14, 1955.

The Riveting of Aluminium. A.D.A. Information Bulletin No. 8. Revised edition. *The Aluminium Development Association*, 33 *Grosvenor-street, London, W.*1. (2*s.*)

This bulletin has been completely revised and enlarged to take into account the results of experience since the first edition was published in 1944. This includes the progress leading to the development of aluminium rivets up to 1 in. shank diameter. The original publication was largely concerned with aircraft practice, while the present edition has been extended to cover the needs of users in riveting every type of structure.

The Wave Drag of Highly Swept Wings: A Comparison of Linear Theory and Slender Body Theory. By T. NONWEILER. Note No. 14. *The Librarian, College of Aeronautics, Cranfield, Bletchley, Buckinghamshire.* (5*s.*)

In this note it is shown that for fully-tapered wings the agreement is exact, and that there is reason to suppose that the same is true for all wing planforms, unless the trailing-edge is unswept, or the wing section has a finite trailing-edge thickness. Some remarks are included concerning the drag of slender delta wings.

Handbook of Hydraulics. By HORACE WILLIAMS KING. Revised by ERNEST F. BRATER. Fourth edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (8 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (57*s.* 6*d.*)

In the new edition of this book there is additional information on orifices and sluice gates, and some of the material on weirs has been improved, the discussion on submerged weirs having been completely revised. The material on pipes, uniform flow in open channels, and non-uniform flow has also been revised and rearranged for greater convenience. The problems of computing critical depth for channels of various cross-sections have been simplified by arranging tables with the variables grouped in dimensionless form.

Testing of Stainless-Steel Weldments. By HELMUT THIELSCH. Welding Research Council Bulletin Series No. 18. *Welding Research Council of the Engineering Foundation*, 29 *West* 39*th-street, New York* 18, *N.Y., U.S.A.* (1 dol.)

A review of published and unpublished information on mechanical tests; procedure-qualification tests; fluorescent and dye-penetrant, radiographic and ultrasonic inspection; sectioning of welded structures; magnetic inspection; corrosion testing; metallographic tests; ferrite, carbide and sigma-phase determination and crack-sensitivity tests. A bibliography is included.

The Inventor of the Valve: A Biography of Sir Ambrose Fleming. By DR. J. T. MACGREGOR-MORRIS. *The Television Society*, 164 *Shaftesbury-avenue, London, W.C.*2. (10*s.*)

This book has been published to coincide with the jubilee of the invention of the thermionic valve. The author is a former student and assistant of Sir Ambrose Fleming. The text is illustrated with many reproductions of original notes and letters, many of which are published for the first time. The present edition of the biography is limited to 1,000 copies.

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BOOK REVIEWS

Introduction to Aeronautical Dynamics. By MANFRED RAUSCHER. *John Wiley and Sons, Incorporated*, 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (12 dols.); and *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (96*s.*)

This title raises the expectation of a treatise on aircraft stability, the problem that, in the author's own words, " is the one in which the different branches of theoretical and applied aeronautical dynamics find their crowning connection." But in this book of 650 pages there are few references to aircraft, and there is no mention of stability in an index containing nearly a thousand entries. The author, in fact, is merely preparing the way for the " crowning connection " by taking the reader in very great detail through the elements of the theory of incompressible flow in fluid mechanics and the three-dimensional theory of rigid mechanics. Quoting again: " Because the chapters on particles, rigid bodies, and vibrations represent about one-half of the book, it would readily be possible to use them for a course rounded out in solid dynamics alone, and the remaining chapters for a course of similar length in fluid dynamics alone."

The justification claimed for this treatment is twofold: first, that it provides for helpful cross-references, and, second, that it was suited to the needs of the author's students at the Massachusetts Institute of Technology. The second of these reasons for combining in one volume what is commonly treated in two was obviously the deciding one, for the book is neither much more nor any less than a complete record of Professor Rauscher's lecture notes in this faculty at the M.I.T. " During the twenty-some years it has taken in the writing," he reveals, " the book was issued piecemeal in the form of mimeographed notes to students taking the subject. Its various parts thus have, in a sense, been published for some time " . . . " In the final editing of the book, I have endeavoured to smooth out the unevennesses in the treatments of the different parts, and to remove such marks of time as I could see here and there " . . . " Particularly noticeable is the lack of discussions of compressible flows in more than one dimension, of thin aerofoils as surfaces of discontinuity, under unsteady as well as under steady conditions, of three-dimensional flow problems, and of servo-mechanisms. My failure to include these topics is due to a lack of time so far to write them up."

Thus the author, in a preface abounding in such frank admissions and explanations, disarms potential criticism to such an extent that a reviewer's first question—should the book have been published in its present form?—may at once be answered in the affirmative, for here is evidence of integrity, discernment and competency. Better indeed had it been extensively rewritten in the light of the author's lifelong experience in the classroom and the research laboratory, but failing the time to complete a task so formidable he has done wisely in committing his mimeographed manuscripts to the printers. To say that the book was worth publishing is not to commend it unreservedly. Some sections, such as the eight-page interlude on the algebra of determinants, must seem completely irrelevant in this country, where the elements of a mathematical background are assumed in comparable courses of study. Some of the results are derived at inordinate length due to the author's insistence on working from first principles instead of using the generalised equations of Lagrange, Euler, or Hamilton; other passages are uncommonly tedious because the author has spared his students the knowledge of elementary vector analysis.

The purpose of an introductory course is surely to equip the student for more advanced work. Much of that equipment in the fields of dynamics and fluid mechanics must necessarily be mathematical, but this book has been written on the assumption that the subject can be mastered with high-school mathematics, supplemented by as much additional technique as the Professor of Aeronautical Dynamics is able to introduce in parenthesis. The explanation of the author's deliberate restriction to the most primitive methods of analysis is, of course, to be seen in the comparatively low standard of high-school education in the United States twenty or thirty years ago, and also perhaps in Professor Rauscher's need, as a good teacher, to lecture down to the intellectual level of the weaker students in large classes. For present-day needs, this collection of lecture notes cannot be regarded as forming the basis of an ideal course in aeronautical dynamics. It will, however, be widely read and appreciated by both students and teachers who need assistance in comprehending or expounding special difficulties arising in a more abstract and formal course.

Radioactive-Waste Disposal in the Ocean. U.S. National Bureau of Standards Handbook 58. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (20 cents.)

This handbook is concerned with one aspect of a matter which is likely to attract increasing attention, both scientific and public, in the course of the next few years. The disposal of radioactive waste raises problems which are in no way confined to large establishments engaged in the production of radio-isotopes or atomic weapons. The increasing use of radio-isotopes in medical practice, agriculture and some branches of industry has created a situation in which radioactive waste may be present almost anywhere and its disposal is a matter of grave concern. This subject has engaged the attention of the Water Pollution Research Board which, in its report for the year 1952, stated that the activated-sludge treatment of sewage could not be relied on entirely to remove radioactive material from the effluent. In view of this, it is not altogether satisfactory to read in this handbook that " where the quantities are small or the half-lives relatively short, unwanted isotopes . . . may be safely disposed of by . . . flushing into the sewage."

This, however, is only an incidental remark which, although it might profitably have been expressed differently, makes the point that the disposal of radioactive waste in quantity raises problems not present when the amount is small. It is pointed out that if there is any foreseeable use for atomic waste, land burial permits of later recovery and that burial sites can be identified and isolated. Neither of these possibilities is present when the waste is disposed of in the ocean. It is recommended that such material should be deposited only in regions where the depth of water exceeds 1,000 fathoms. There will be no disagreement from the remark that " unfavourable situations might arise if a package of radioactive material were found on the shore or recovered in a fisherman's net."

Although it is suggested that radioactive waste might be prepared in the form of insoluble pellets or briquettes of high density, the main recommendation is that it should be packed in containers built up of steel and concrete and that no voids should be left as they might result in rupture by hydrostatic pressure. The containers should be of convenient shape and weight for transport and should shield those handling them from dangerous radiation. As under the present constitution of the world anybody may dump anything anywhere in the high seas, outside the three-mile limits, this matter of the disposal of radioactive waste in the ocean raises questions which, as this handbook points out, are of international importance. This publication of the National Bureau of Standards is a valuable contribution towards their solution.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

General Machinery and Plant. GEORGE COHEN & SONS, LTD., Broadway Chambers, London, W.6. Power plant; A.C. and D.C. generator sets; Diesel engines, steam engines, condensers, air compressors and receivers, pumping sets. Electrical equipment; A.C. and D.C. generators and motors; switchboards, circuit-breakers, starters and transformers, steam boilers, heating boilers and radiators. Process plant; driers and furnaces; mixers; air conditioning and refrigerating plant. Corrosion resistant plant. Hydraulic plant, rubber and plastic machinery. Contractors' plant; machine tools of many types. Comprehensive illustrated catalogue arranged in sections with general index.

Lubrication of Earth-Moving Machinery. C. C. WAKEFIELD & CO., LTD., Wakefield-Dick Industrial Lubricants Division, 46 Grosvenor-street, London, W.1. Comprehensive survey of lubrication for all parts of earth-moving machinery; bearings, transmission, wire ropes and lifting chains, hydraulic equipment, air compressors and compressed-air tools, Diesel, petrol and paraffin engines, running gear; notes on storage of the machinery, and on typical troubles; details of Wakefield lubrication equipment, and recommended grades of lubricant. Booklet with excellent explanatory drawings and some photographs.

Atomic Energy. MUREX, LTD., Rainham, Essex. A review by Mr. E. C. Pigott of present knowledge of atomic energy. Brief account of underlying theory and history; military use in atomic bomb and subsequent development of hydrogen bomb; survey of application to peaceful purposes. Booklet with photographs, diagrams, bibliography and abstracts, published by Murex, Ltd., as Issue No. 14, Vol. 1, of their *Review*.

Corrosion Preventives. C. C. WAKEFIELD & CO., LTD., Wakefield-Dick Industrial Lubricants Division, 46 Grosvenor-street, London, W.1. Problem and causes of corrosion, nature and types of temporary corrosion preventives, details of application and removal of preventives. Booklet with drawings and photographs.

Ground Thread Taps. ALFRED HERBERT, LTD., COVENTRY. Manufacture and design of taps, hints on tapping, lubricants and cutting speeds for various materials; tables of tap dimensions and zone tolerances for all sizes and standard forms of threads. Illustrated booklet.

Electrical Accessories. M.K. ELECTRIC, LTD., Edmonton, London, N.18. Socket outlets and plugs with and without switches; adaptors and fuse boxes; switches; and cooker control units. Technical details and dimensions. Fully illustrated price list.

Electric Control Gear. G.W.B. FURNACES LTD., Dudley, Worcestershire. Heavy-duty contactors and components for electric control gear. Leaflet giving concise details of new range. Also catalogue of full range of control gear manufactured.

Waterborne Epidemics. WALLACE AND TIERNAN, Ltd., London, W.4. Reprint of paper "Waterborne Epidemics," by Dr. W. H. H. Jebb, M.A., M.D., presented at a meeting of the Society for Water Treatment and Examination.

Welded Fabrication. LINCOLN ELECTRIC CO., LTD., Welwyn Garden City, Herts. Use of welded steel to cheapen production costs. Illustrated leaflet, first of series entitled "Origineering."

Impact Wrench. HOLMAN BROS., LTD., Camborne. Brief technical description and uses of "404" impact wrench, for use up to ¾ in. heavy duty and 1 in. normal duty. Illustrated leaflet.

Precision Indicator Gauge. SMITH METERS, LTD., Rowan-road, London, S.W.16. Comparators for checking dimensions to 0·0002 in.; pillar and bench models. Illustrated booklet.

Small Tools. R. STOCK & CO. Berlin-Marienfelde. "Hartex" taps with sub-divided thread profile. Catalogue with comprehensive tables of dimensions and thread data.

Scraper Chains. BRITISH JEFFREY-DIAMOND, LTD., Wakefield, Yorkshire. Scraper chains for use in coal mines. Pamphlet showing manufacture and construction pictorially, with brief specifications.

Aluminium Steps and Ladders. W. A. LLOYD'S ALLOYS, LTD., Droitwich. "Handylad" steps; single section, tripod, dual and triple extension ladders. Two illustrated leaflets.

Files and Chisels. WILLIAM SMITH TOOL AND STEEL CO., LTD., Harrow-street, Sheffield 11. "Despatch" files and chisels. Two illustrated booklets.

Autumn Meeting of the Iron and Steel Institute (*continued from page* 683)

THE FUTURE OF STEEL MELTING

IMPROVED AND ALTERNATIVE FURNACES

At the conclusion of the formal business on the morning of Wednesday, November 17, the first day of the annual autumn meeting of the Iron and Steel Institute, reported in our issue of last week, the meeting turned to the presentation and discussion of papers.

The first contribution considered dealt with "The Future of Steel Melting," and was by Professor M. W. Thring of the Department of Fuel Technology of the University of Sheffield. In presenting it, he stated that the fuel consumed in making steel would absorb an increasing portion of the cost of the process as supplies of fuel became scarcer. Hence, the thermal efficiency of the process would have to improve; the best value, at present, was just over 20 per cent. The likely effects of applying flame control in the furnace, namely, of adjusting the flame length and the emissivity of the flame, could be shown with the aid of a theoretical model. Flame-radiation research at Ymuiden had indicated that it was possible to control the flame length for liquid fuel or rich-gas flames within wide limits by controlling the jet momentum. There was little doubt that the best flame for melting in an open-hearth furnace was that which had the highest obtainable emissivity. At present, this was controllable only by changing the fuel type.

It might be concluded that the Siemens open-hearth furnace could be brought up to an overall thermal efficiency of the order of 50 per cent. by various steps, of which the most important were an increase in the efficiency of the regenerators to give an air preheat temperature of 1,400 deg. C. Beyond this the Siemens furnace could not go, because it did not provide the ideal temperature cycle for the heat requirements of steelmaking.

An improved steelmaking process based on the counterflow continuous principle could give efficiencies up to 70 per cent. with a 100 per cent. cold-metal process. A continuous counterflow steelmaking plant would be fired at one end with one-way coke-oven gas or oil burners operating with air preheated to 750 deg. C. in a recuperator. The horizontal chamber of the plant acted purely as a refining chamber and the steel flowed through this in 2 hours, since the thinner slag and shallower bath, possible with a continuous system, would considerably accelerate the refining reactions.

DISCUSSION

The discussion was opened by Mr. J. Mitchell, C.B.E., who stated that in his opinion the author was overlooking—though he had stated them clearly—the disadvantages, both thermal and metallurgical, of the open-hearth furnace and the fact that there were alternative means of steelmaking, and that probably the future lay in that direction. The author had made a great point, and rightly, of the advantages which he would derive from a thin slag and a thin bath, but these advantages were purely illusory unless there was an intimate contact between the slag and the metal, and that was precisely what would not happen. The new furnace would melt down cold pig-iron fairly well, but not scrap.

There was only one way to overcome the disadvantages of the open-hearth process and that was to accept the somewhat revolutionary idea of generating the heat in the metal instead of trying to push it through the slag. The process in which this was done was the converter process. With the new oxygen techniques there was a superheat in the metal which made it possible to use from 30 to 40 per cent. of scrap.

Dr. A. H. Leckie submitted that the steel industry was not particularly backward in its ideas, and the Siemens furnace was still in full activity because it was the best for its particular task. In stating that, he did not question Mr. Mitchell's contention that converter processes were equally good. He was thinking of where it was necessary to deal with 55 per cent. of scrap. The author was not fair to the Siemens furnace, because he had not discussed one or two of the subsidiary points which made it better than theory suggested.

The main difficulty was that it was necessary to send a great deal of high-temperature heat out of the working chamber, and regenerators could recover only part of this. Most modern open-hearth furnaces, however, had waste-heat boilers. If the author were to give the theoretical efficiency of the best possible Siemens furnace equipped with the best possible waste-heat boiler, this would come more in the region of 65 to 70 per cent. than the 50 per cent. maximum given in the paper. The heat recovery potential of the waste-heat boiler should not, of course, be used to excuse inefficiency; a steelworks should make steel, not steam, as the author had said; but there would always be a steam potential, and that should be taken into account when considering fuel saving, just as when working out the efficiency of a blast-furnace the credit from the gas going out of the top must be taken into the calculations.

There were also chemical criticisms of the author's process; the oxygen potential required to burn fuel efficiently would "burn" iron very efficiently, and the only reason why scrap, melted in the Siemens furnace, was not over-oxidised was that it was covered with slag; it was saved by the very feature of the Siemens furnace which the author condemned on grounds of heat transfer.

SULPHUR PICK-UP

Another point to be considered was whether the author was satisfied that there would not be sulphur pick-up? He had said that one of the advantages of his proposal was that because the gases were fully burnt long before they came in contact with any metal . . . sulphur pick-up could be almost completely eliminated, but sulphur pick-up was quite serious even from completely burnt fuel if there were exposed iron and iron oxide, so that the new furnace would not help in that direction. It might be better than the Siemens furnace, but it would not overcome the problem of sulphur pick-up.

At the end of his paper the author had mentioned atomic energy. This was very much in the public eye. So far as could be seen, its only application would be through the use of electricity.

Dr. J. H. Chesters suggested that if this idea of the author were tried out—and he had good reason to believe that it was going to be—then the people who tried it out, if they did nothing else, would learn a great deal about such matters as convection heat transfer, about which there was a good deal of academic talk. These problems came up in all sorts of other fields, and this was one way of getting the information. He felt, therefore, that experimentation should go forward, even though there were many obvious obstacles.

He agreed with Dr. Leckie that the author's estimate of the efficiency of the open-hearth furnace was pessimistic, and that it would be fairer to include waste-heat credits. He also felt that steel men were not by any means at the end of the road so far as the conventional open-hearth process was concerned. There was still a great future in intense combustion. He thought that a figure for liquid-fuel consumption, allowing a reasonable credit for steam, even for a cold-charged furnace, of something less than 20 gallons per ton was not an impossible target.

It was not easy to achieve, and he did not expect to see it achieved for ten or twenty years, but it was not impossible.

Dr. T. P. Colclough, C.B.E., said that metallurgists were all fully conscious that the open-hearth furnace was not an efficient instrument. The preferable way of approaching this problem would be to make a critical examination of why it was not so efficient and to see what steps could be taken to overcome the difficulties. In 1922 a paper had been read before the Institute giving what was probably the first heat balance of an open-hearth furnace. The efficieney which had been derived was 17 per cent. Some progress had been made, because he believed that furnaces were operating at present in which this efficiency had been at least doubled.

SCRAP MELTING BY WASTE HEAT

Turning to details, he said that the waste heat leaving the author's new furnace was used to melt scrap in a cupola-type chamber. The paper stated that the cupola for melting this scrap would be 10 ft. in diameter and 86 ft. high. Was it possible to visualise a chimney 86 ft. high at the end of an open-hearth furnace? (Professor Thring here interposed with the statement that there was a misprint in the paper; the figure was 8·6 ft., not 86 ft.)

Continuing, Dr. Colclough said that he did not know whether the author had given any consideration to the building of this chimney. Metallurgists had some experience of melting scrap in cupolas, and the longest time for which one could be constructed to stand up to the task was about eight hours in a reducing atmosphere. What would happen in this case, with the scrap being melted in an oxidising atmosphere and the formation of ferrous silicates which would be running down the walls, could be left to the imagination.

The open-hearth furnace must be improved in efficiency. It was said to be inefficient because, in order to maintain the speed of operation, cooling had to be employed and a large amount of heat was carried away in water cooling. The regenerator chambers, however, were efficient to a not unreasonable degree. Brick regenerators could be, and were, built with an efficiency of 90 per cent. The reason why an open-hearth furnace was not efficient was that the regenerator system was not built in the correct way. If it were desired to extract more heat from the waste gases (which was the way in which efficiency was improved) metal recuperators should be put in at the end of the present regenerators. This had been done. It was not a new idea. It had been, he believed, first introduced at Corby, where metal recuperators had been put on the end of the regenerator chambers of soaking pits, in order to make them operate on blast-furnace gas.

Professor M. W. Thring, on being called upon to make an "interim" reply to the discussion, stated that he was delighted that his paper on an alternative process was producing defenders of the open-hearth furnace who were suggesting ways in which it could be improved. He agreed with all these points—putting recuperators after regenerators, making the furnace tight, eliminating water-cooling, and so on. The paper would have been useful if it had persuaded people to do these things on the open-hearth furnace. In spite of all the criticisms made, however, he believed that the process which he was proposing represented a radical improvement. He agreed that it required more working out; his paper was rather tentative, and it contained some misprints.

On the question of sulphur, he had said in the paper that if the sulphur were fully oxidised before the flame hit the bath, there would be less of a sulphur problem. It might be that such was not the case. He agreed that the problem of the brick lining of the chimney was a considerable one, but he did not think that it was insoluble. The thickness of the slag in the furnace was a very debatable point. He had deliberately assumed a very thin slag and a very thin bath, because the real problem with steelmaking was to get contact between the slag and the steel, and if they were both thin the molecules did not have to move so far to reach the surface of contact, and that was an advantage.

Dr. Leckie had asked about atomic energy. He agreed with him in not seeing any way of using it for steel melting except as electricity.

Dr. J. Pearson, who next took up the discussion, said that the author had stated that, in his furnace, "The steel flowed through the refining chamber in 2 hours, since the thinner slag and shallower bath possible with a continuous system would considerably accelerate the refining reactions." He (Dr. Pearson) did not think that there was any evidence at all for that. Even with conventional bath depths, most refining reactions appeared to proceed quite fast, with the possible exception of carbon removal.

In the matter of sulphur, the mechanism of its pick-up was not known completely, but present knowledge would lead to the conclusion that the proposed furnace would be about the worst which could be imagined for sulphur. It had a scrap-heating column, and steel without slag cover was subjected to the action of gases containing a good deal of sulphur. Finally, the author had done away with the large doors and put tiny peepholes at the side. How would he fettle his furnace? At the base of his scrap column he would have a great deal of wear, and he would probably have to put charging doors back simply to get the fettling done.

Dr. C. A. Edwards, F.R.S., agreed with what had been said concerning sulphur pick-up. The author's proposal would probably lead to very much more sulphur pick-up than now obtained in the ordinary open-hearth furnace, because the whole of the scrap was being exposed during the whole of the melting period to the waste gases, whereas in the ordinary basic open-hearth, as at present used, a good deal of scrap was well below the slag level as soon as hot metal was put into the furnace.

He was not sure whether, at the bottom of his column, the author would get any metal at all, because the extent of the oxidation would be so great that it would be largely oxide of iron which would be flowing there and this would be very corrosive.

Dr. J. H. Chesters, in a further contribution to the discussion, said that one of the real functions of this type of paper, and the kind of work it called for, was to get investigators out of a groove. The speakers who had criticised the project had done so on several grounds. One was that the author was not in a position to say whether this type of apparatus would, or would not, remove carbon faster than the normal furnace. Secondly, it was also said that there would be a very high sulphur pick-up, but that the author was not in a position to calculate it. Thirdly, it had been stated that what came out at the bottom of the column would be molten scale and, furthermore, that nothing would come out of the furnace and that the charge would stick. Finally, it had been said that the heat transfer in the column could not be calculated because the fundamental data to do so did not exist. "I suggest," concluded Dr. Chesters, "that when this 'abortion' has been built and operated for one year we shall at least have preliminary answers to all those questions."

AUTHOR'S REPLY

Professor M. W. Thring, in a final reply, said that the discussion had begun with a suggestion that the open-hearth was not the process of the future at all, but that the Bessemer was the process of the future. He had hoped that some of the later contributors would have answered this. They had done so to some extent by saying that the open-hearth was much better than he had supposed. He agreed with these comments. If the paper made the open-hearth "pull its socks up," so much the better. Suggestions had been formulated by Dr. Colclough for putting recuperators at the end of the regenerators, for the elimination of leaks in the open-hearth, and for the elimination of water cooling, while Dr. Chesters had referred to intense combustion. It was clear, therefore, that the open-hearth could go a long way further than it had gone already.

There was still room, however, for trying to answer criticisms of the new process. To summarise them, first of all there were the criticisms about what happened in the bath of the proposed process, and Dr. Pearson's criticism that under the flame there would be sulphur pick-up by the outgoing steel, because the gases were not fully burnt. To some extent Dr. Pearson's two criticisms concerning sulphur were self-contradictory, because on the one hand he had deprecated the presence of unburnt gases and stated that there would be a lot of pick-up there, and, on the other hand, he had said that even when the gases were fully burnt in the column pick-up could still occur.

Some of the arguments raised against the new furnace answered themselves. Apparently the open-hearth furnace managed to get good heat transfer to the scrap and not to oxidise the scrap and not to have sulphur pick-up because the scrap was always underneath the slag cover, and it got a good heat transfer through the slag cover. He (Professor Thring) criticised it on that point and said that it was because it was under the slag cover that it was difficult to get heat in.

The answer to the questions of the processes in the column was that given by Dr. Chesters—try it and see. Why, for example, did not the flame in the present open-hearth furnace oxidise all the scrap which was piled up, before it melted it down?

It had been said that the refractories would not stand up to the conditions, and there again only actual trials could give the answer. He did not think that the refractory makers would admit that this was an impossible problem.

It had been said that it would be impossible to fettle the bath. There was always a tendency to think in terms of a process which had been operated for the last hundred years. With a semi-continuous or continuous process the fettling problem would probably be quite different from the present one. At present the bottom of the bath had to stand all the different stages in the melting process and therefore had to be a compromise between the ideal materials for all these stages. With a semi-continuous or continuous process the material would be right for each stage at the right place, and material which would last longer than it did at present could be used, so that it would only be necessary to patch up the bottom once a week when the furnace was emptied.

The position could be summarised by stating that metallurgists did not know enough about the new process at present to say that it would work, and therefore the best answer would be to try it and see. Even if it failed a great deal would have been learnt about the metallurgy of steelmaking and this would be useful in improving the open-hearth furnace.

To be continued

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SYMPOSIUM ON METAL-PHASE TRANSFORMATIONS

The Metal Physics Committee of the Institute of Metals is proposing to hold, in London, a one-day symposium on "The Mechanism of Phase Transformations in Metals," at a date which will probably be in November, 1955. The morning session of the symposium will be devoted to transformations which are largely governed by thermal activation (nucleation and growth reactions) and the afternoon session to transformations in which thermal activation is less important, such as martensitic reactions. Review papers are to be prepared to introduce each session, but, in addition, the Committee will be glad to consider offers of short original contributions of up to 3,000 words from investigators in the field of phase transformations. Further particulars are obtainable from the the Editor, The Institute of Metals, 4 Grosvenor-gardens, London, S.W.1.

THE DEVELOPMENT OF THE THERMIONIC VALVE

The development of the thermionic valve during the 50 years since Professor J. A. (afterwards Sir Ambrose) Fleming applied for a patent for "improvements in instruments for detecting and measuring alternating electric currents," was the occasion of a meeting at the Institution of Electrical Engineers on Tuesday, November 16. The President (Mr. J. Eccles) was in the chair and the proceedings were opened with an address by the Lord President of the Council (the Marquess of Salisbury, K.G.). Subsequently lectures were delivered on "The Genesis of the Thermionic Valve," by Professor G. W. O. Howe, Emeritus Professor of Electrical Engineering in the University of Glasgow; on "Thermionic Devices from the Development of the Triode up to 1939," by Sir Edward Appleton, G.B.E., K.C.B., F.R.S., Principal and Vice-Chancellor of the University of Edinburgh; and on "Developments in Thermionic Devices since 1939," by Dr. J. Thomson, Deputy Director of Physical Research, Admiralty.

In his opening address the Lord President of the Council said that recent discoveries for the most part advanced from the solid base of ascertained fact. It was to this modern school that Fleming belonged, since his work followed a trail that had already been blazed, although his inspiration carried him forward so that he might claim credit as being the first to discover the thermionic valve.

The principle of the thermionic valve had pointed the way not only to wireless transmission, television and radar, but to the employment of electronics in the industrial field.

FLEMING AND DE FOREST

After giving a brief biography of Fleming—since to many younger members of the Institution he was little more than a name—Professor Howe recalled that in 1884 Edison had fixed a metal plate in the bulb of a carbon filament lamp; and had found that if this plate were connected through an external galvanometer to the positive terminal of the filament a current flowed. If, however, it was connected to the negative terminal no current was indicated. Fleming came to the erroneous conclusion that this phenomenon, which was known as the Edison effect, was due to a transfer of the electric charge by atoms of carbon. It was not until 1899 that J. J. Thomson showed that it was caused by the emission of electrons. In 1904, it occurred to Fleming that the Edison effect could be used to rectify high-frequency alternating currents; and he applied for a patent on November 16, 1904, which was the basic reason for the present gathering. Fleming's valve was, however, simply a rectifier or detector. It was in no sense an intensifying device.

Two years later, in 1906, Lee de Forest invented a triode valve, or audion, in which a metal plate was fixed near a carbon filament in an exhausted bulb and a zig-zag wire, or grid, was placed between the plate and the filament. While, therefore, Fleming must be given the credit of being the first to apply thermionic phenomena to detection, the intensifying properties of de Forest's triode were more important to-day.

THE PATENT SITUATION

The resulting patent situation gave rise to considerable litigation, the outcome of which was that the American courts decided that de Forest's addition of the grid, though a contribution of value, was not independent of Fleming's invention. De Forest, therefore, could not make three-electrode valves without infringing Fleming's patent, and the Marconi Company, to whom the latter's rights had been assigned, could not make them without infringing de Forest's patents. Great confusion followed, which was not removed until Fleming's United States patent expired in 1922. Even this was not the end of the story for, in 1943, the American Supreme Court decided that Fleming's patent was invalid on the grounds that he had claimed more than he had invented.

INTER-WAR PROGRESS

Professor Howe's argument was supported by Sir Edward Appleton, who said that the answer to the fundamental question—Who put the third electrode into the Fleming valve?—was without question Lee de Forest. This was shown by the third claim in the patent which the latter was granted in the United States in 1908.

Although the de Forest audion was one of the great inventions of history some years elapsed before its mode of operation and possibilities were recognised. Development resulted from the experiments of E. H. Armstrong, which were designed to elucidate its operating features, and from the work of Langmuir and his colleagues who produced vacuum tubes with pressures a thousand times smaller than had been previously attainable. Armstrong's two papers in which he sought to interpret the action of the audion as a detector and amplifier in terms of experimentally-determined curves were published in 1914 and 1915; and their contents would be accepted, in the main, as correct to-day.

These papers, which Sir Edward briefly summarised, gave rise to a discussion in which de Forest played an ungracious part. He still regarded the presence of gas in the tube as an essential feature and advanced the view that the current between the hot and cold electrodes was entirely thermionic.

In the meantime, H. J. Round in this country produced the famous V24 and Q valves and directed his attention to circuit needs, while C. S. Franklin discovered the phenomenon of feed-back for high-frequency amplification and a number of people found that a triode could be used as a generator of radio oscillations. The 1914-18 war was a period of intense three-electrode valve development. It killed the soft valve, since what was required was reliability and constancy in operation, as well as uniformity in performance between valve and valve. In this field Ferrié and Gutton in France and B. S. Gossling in this country did outstanding work. From the scientific point of view, however, the chief result of the war was an understanding of how the valve worked and how its performances was determined by its internal physical dimensions and structure.

LIMITATIONS OF THE TRIODE

Although by the end of the first World War the triode was the only valve in use as a detector, amplifier and generator of high-frequency oscillations, its limitations were recognised. This led to the introduction of the screen grid by Round in 1926, so that the capacity between the control grid and the anode could be cut down to one hundredth or a thousandth of a micro-microfarad. This tetrode, however, gave rise to secondary emission, to remove which a suppressor grid was introduced. Another type of valve was developed to permit the output of a receiver to be adjusted to any desired level without distortion, by varying the pitch of the control-grid winding.

Near the end of this period the diode came into fresh use as a high-frequency detector and for automatically controlling the grid bias on variable-mu valves. More complicated types of electrode structures resulted, although these did not introduce any fundamentally new principles. A further important development was the electrometer triode, which might be considered as a rival to the string electrometer. There were also "grid-leak" and "anode-bend" voltmeters, a slide-back voltmeter for measuring the peak voltage, using a triode filled with mercury vapour or argon, and triode and hexode wattmeters.

Concluding, Sir Edward said that by the beginning of the second World War the triode—as generator, amplifier and detector—had vastly expanded the scope of our most natural modes of communication—the voice and ear. It had also become one of the most important tools of scientific research, replacing mechanical devices wherever a delicate and nimble indicator was required. Physiologists were using it for studying electrical impulses in the human frame, the nuclear physicist was employing it to count the atomic products of his explosions and to examine other rapidly occurring events.

PROGRESS SINCE 1939

In the concluding lecture, Dr. J. Thomson said that the advances made in valve design since 1939 were rapidly leading to the point where broad-band amplifiers of adequate power gain and efficiency would be available for transmitters at all wavelengths down to millimetre waves, while superheterodyne receivers, tunable over an octave and having noise factors of only a few decibels, would be produced for the same band of frequencies.

Describing the valves which could be employed on microwavelengths, he said that the Klystron could be linearly modulated up to 100 per cent., if the modulation were high level. There was also no fundamental reason to suppose that low-level modulation was impossible; and a microwave system using it and with a reasonable band width would be a valuable tool for the radio engineer. Since a Klystron gave a gain of 1,000 such a device would be a direct-current amplifier of outstanding performance. The first British valve to use low-level pulse modulation operated at a frequency of 1,000 megacycles and had an efficiency of 40 per cent. It might be useful for colour television. A travelling-wave tube operating at 7·5 cm. was used by the Post office and was the first to be employed in a relay system.

CONDITIONS FOR A NEW VALVE

Anyone who wished to invent a new valve was faced with two possibilities: either to find a different way of coupling an electron stream to the electromagnetic circuit, which would be extremely difficult; or to discover some more efficient way of using known methods. That would be feasible with velocity variation, but would be difficult with space-charge modulation, since the efficiency of a good Class C amplifier was already over 90 per cent.

The ordinary valve used in domestic radio was not robust enough for employment in factories, aircraft and other positions where shock and vibration were present. Serious attempts were being made to overcome this difficulty, and continuous search was being made for more satisfactory electrode and insulating materials. It had been found that if valves were baked at 700 to 800 deg. C. the cathode emission and life were greatly improved. The communication engineer wanted valves with a life of 100,000 hours and research into new materials would therefore pay large dividends.

A VALVE EXHIBITION

As part of the celebration an exhibition of valves numbering some 250 specimens was arranged at the Institution. This included the original valves used by Fleming in his researches into the Edison effect and the actual specimen with which he succeeded in rectifying high-frequency currents. The display indicated in an informative manner the progress that had been made through the triode of 1907, the hard valve of 1915, the tetrode, pentode and heptode of the late twenties and thirties to the electron multiplier of 1936, as well as the development of the Magnetron, Klystron and travelling wave tube.

Fleming's work was also celebrated at University College, London, where his investigations on the diode were carried out. A plaque was unveiled by Lord Salisbury and a number of instruments were assembled to emphasise the limitations under which Fleming's work was carried out.

ENGINEERING GOODS IN THE COLONIES

1—POST-WAR STABILITY AND PROSPERITY

One of the few compensations for the high price which the British public has to pay these days for its chocolate, sugar and coffee is the fact that much of the money is channelled into countries which are highly geared to increase their capital investment. Never before has so much time, money and technical advice been poured into the underdeveloped territories of the world. Fortified by funds from the high price received for the products which they export and from grants or loans from industrialised countries, such territories are programming and carrying out major schemes in land utilisation, new roads, better water, and more electric power. By developing these basic services these countries are helping to industrialise their economy, establish new industries and so raise the standard of living of their people. Among them are the British Colonies which benefit in this respect not only from being scheduled as underdeveloped when it comes to the receipt of loans from the World Bank, but also from their unique relationship to the United Kingdom which provides them both with a market for their products and a source of capital.

The British Colonies have for long provided a useful market for engineering equipment, notably for mining machinery and plant connected with public utilities. The indications are that these territories are becoming increasingly important as an outlet for British engineering goods in general.

PERMANENT OR TEMPORARY DEMAND?

In Table I, below, the history of the growth of the export of engineering products to the Colonies is set out for the post-war years, compared with 1938. As the bottom line of this Table shows, the Colonies have taken an increasing proportion of Britain's engineering exports since the war. Since 1938, British exports have increased from £471 millions to £2,582 millions in 1953, that is by about 450 per cent. Exports of engineering goods as a whole have gone up from £125 millions to £1,037 millions, or 730 per cent. over the same period. In the case of exports to the Colonies, however, there has been both a large absolute increase in the total engineering exports to them from this country (until 1952) and a significant increase in their proportion of total engineering exports from the U.K. In 1953, there was a slight decline, due mainly to a fall in imports of machinery (not electrical equipment, however) from Britain and the indications are that this fall will be continued to some extent in 1954. On the basis of six months figures for this year, shown in Table I, the total exports of engineering products to the Colonies for 1954, is likely to be about £110 millions (exports in the second half of the year to these areas are usually slightly higher than in the first half). This decline is not likely to go any further, however, as long as the prices for Colonial commodities remain as buoyant as they are at present. It can therefore be said that the Colonies take no less than 10 per cent. of the engineering exports of the United Kingdom, which is twice as much as pre-war.

This fact is important. It means, of course, that the Colonies are a much more important market than they were pre-war to engineering companies. But the critical point is this. Before the war the capacity of the Colonies to import engineering equipment changed violently even from year to year. They were on the whole poor countries which occasionally received a windfall in the form of high prices for their exported produce. This meant temporary buoyant excise revenue and the ability of the local Government to carry out public works. There was little impetus towards general industrialisation except in those Colonies where the mining industries flourished. These were, to some extent, a stabilising influence. The question now arises, how far can engineering concerns expect their colonial markets to be stable now that they absorb not about £6 million worth of engineering equipment a year but at least £100 million worth? Is this to be regarded as a windfall for both parties, or have the colonial markets expanded for an indefinite period and are they worth serious and systematic further development?

Table II shows imports of engineering equipment by the main geographical areas for 1938 and from 1949 to 1952. These figures are, of course, total engineering imports not the engineering imports from the U.K. In 1938, the main markets were Central Africa, British West Africa and Malaya, followed by British West Indies and Hong Kong in that order. Some distance behind this came British East Africa. By 1952, all markets had expanded notably, measured in terms of value, but the largest increase had occurred in British East Africa. The West Indies and Hong Kong have become relatively less important although even Hong Kong was doing four times as much trade in terms of the value of engineering goods handled as it was in 1938. The effect of the change of emphasis has been to suggest that Malaya is about as attractive a proposition as a market as it was before the war compared with other Colonies, but tropical Africa has moved up slightly taking 49 per cent. of engineering imports from all sources in 1938, and 52 per cent. in 1952. No figures are yet available for 1953 and 1954, but it is not likely that the pattern has changed since 1952. If the figures in Table I are compared with those in Table II it is apparent that British engineering exports have gained ground in the Colonies. In 1938, they accounted for about a quarter of total engineering exports to these areas and in 1952, they accounted for about half. Much of this improved position of U.K. companies has been due, of course, to the dollar shortage. What grounds are there then for thinking that these encouraging results are not just a windfall in a volatile market?

THREE QUESTIONS

If an encouraging answer is to be given, three questions have to be answered. First, since these areas must in the main depend for an indefinite period for their prosperity on good export prices, what is the likelihood that prices will in fact remain near present levels? Second, since it is likely that for an indefinite period a good deal of capital investment in these areas will have to be encouraged by the colonial Government concerned, what is the likelihood that these areas will have a better record of fiscal stability than pre-war? Third, how far is it likely that these areas will become decreasingly dependent on the export of produce for their prosperity owing to further industrialisation?

The prospect for good export prices depends on two factors—sustained demand and adequate local financial reserves to meet temporary declines in prices. This is tantamount to asking what are the prospects for West Indian sugar, West African cocoa and edible oils, East and Central African coffee, tobacco and minerals, and Malayan tin and rubber? The outlook for these commodities is good provided that consumer purchasing power is maintained in Western Europe and North America, that substitute consumer goods for high priced coffee and cocoa are not developed, that industrial production remains buoyant in Western Europe and North America to absorb Colonial minerals, and that the statistical position of the commodities is good at the outset. By statistical position is meant that the market is not burdened with large stocks from a past period of over-production.

TABLE I.—UNITED KINGDOM EXPORTS, 1938 AND 1949-54

—	1938	1949	1950	1951	1952	1953	Jan.-June, 1954
Total U.K. exports £ millions	471	1,785	2,171	2,580	2,582	2,582	1,344
Exports of engineering products to the world £ millions	125	718	859	1,005	1,075	1,037	503
Exports of U.K. engineering products to the Colonies £ millions	6	31	87	115	131	119	51
Exports of engineering products to the Colonies as per cent. of total	5	4	10	12	12	11	10

TABLE II.—*Imports of Engineering Goods into Main Colonial Areas.* (£ millions.)

—	1938	1949	1950	1951	1952
British West Indies ..	4	12	14	17	18
West Africa ..	5	19	22	26	33
East Africa ..	2	28	21	26	32
Central Africa	5	29	29	36	44
Malaya ..	5	14	22	38	39
Hong Kong ..	3	10	11	17	12
Total ..	24	112	119	160	178

Note.—West Africa includes Nigeria, Gold Coast, Sierra Leone and Gambia; East Africa includes Kenya, Tanganyika and Uganda; Central Africa includes Southern Rhodesia, Northern Rhodesia and Nyasaland; Malaya includes all the Federated States and Singapore; British West Indies includes British Guiana, as well as the Caribbean Islands.

RUBBER AND TIN

The picture on the whole is reassuring. It is evident that Commonwealth sugar producers are going to have a price agreement for an indefinite period with this country and that it will be politically impossible to pitch the price too low for the comfort of sugar producers in the Colonies so long as prosperity continues in the United Kingdom. Cocoa and coffee prices have been inordinately high of late, due in part to the revival of demand in Western Europe, notably in Germany. There have been signs that chocolate manufacturers in the United States (who take the major part of the West African cocoa crop) have tried to develop substitutes for cocoa but there is little sign of outstanding success as yet. It seems probable that cocoa and coffee prices could fall 10 to 20 per cent. without seriously endangering the economies of West and East Africa and so rule out the possibility of substitutes gaining ground in the foreseeable future. None of these consumer goods are troubled at the moment with large stocks to liquidate. So far as the metals are concerned, Central African copper is the cheapest in the world and its prospects are good. The tin market is in a statistically sound position thanks to U.S. stock-piling, and the recently initialled international tin agreement should prevent the market from becoming flooded with supplies. Rubber is recovering after a period of uncertainty about its competitive power against synthetic rubber and the political troubles in Malaya. Of all the areas, Malaya with its dependence on tin and rubber seems to be in the most vulnerable position, but these two commodities have seemed to be in a weak position ever since the war. (The high price of tin has encouraged the use of substitutes and the high price of rubber has encouraged the development of synthetic rubber.) But the area has been able to remain remarkably prosperous. On the whole, therefore, the outlook for

the Colonies so far as their exports of produce is concerned, is good.

So far as fiscal stability is concerned, many of the Colonies, though not all of them, have been able to put to reserve large funds over the last 15 years. Many of them had guaranteed prices for their produce during the war and since they could not use their balances resulting from these guaranteed prices to purchase imports from the sterling area (the Colonies were rationed just as the U.K. was), they accumulated large sterling reserves in London. These reserves have been added to since the war because export prices for their produce have remained high and heavy excise duties have siphoned off substantial amounts into local Exchequers. The extreme case of a new-found comparatively stable prosperity based on export produce is the Gold Coast, which, owing to the soaring price of cocoa, has been able in the last few years to budget for a surplus on ordinary income and expenditure account which was as much as one fifth as large, as the entire national income 20 years ago. Both Nigeria and the Gold Coast have been able to use the remarkable prosperity of cocoa to build up reserve funds to support the cocoa price in years of depression and to make substantial contributions to the exchequer for the general development of their economies. It is this new-found prosperity arising from cocoa, for example, which makes the Gold Coast so anxious to go ahead with the Volta hydro-electric and alumina scheme. Prosperity has in fact reinforced all the colonial exchequers in Africa and they have all been able to make substantial contributions to capital development projects out of their own funds as well as receiving grants from the United Kingdom under the Colonial Development and Welfare Acts. The fiscal outlook in the West Indies is less encouraging perhaps than in the case of the African colonies, but even here there has been an improvement since the war.

The outlook, for industrialisation in the Colonies, so that they can reduce their dependence to some extent on exports of produce, is good but not as good as some of the optimists think. Much depends upon the conditions in individual colonies and this matter will be dealt with more fully in the second of these articles. For the moment we are concerned only with the broad issues. The Colonies need raw materials, skilled labour and management, technical assistance and finance if they are to develop along industrial lines. It is a hard doctrine for some people to accept but no amount of technical assistance and finance will establish industries where there are no raw materials to start with nor proper estimates made of markets. All the Colonies now have development programmes which follow a broadly similar pattern. They are concentrating on new roads, electric power installations, improved water supplies, secondary industries, housing, health services and education. Their critics argue that rather too much money is being spent on the last three of these. Be that as it may, coherent plans exist for industrial development based on realistic assumptions about available supplies of raw materials and manpower. The funds made available under the Colonial Development and Welfare Act, already referred to, have been designed to provide an initial sum to be used at key points in these plans and subsequently supplemented from local resources to touch off a long-term programme of development and in some cases of industrialisation.

There has been a good deal of quiet success and a certain amount of spectacular much-publicised failure. Assistance has been given in many Colonies by the Colonial Development Corporation as well, and here, too, the failures have received more notice than the successes. The level of engineering imports to the Colonies has been raised for two reasons: increasing industrialisation, and continued expansion of the mining companies who have always provided economic stability. The significance of these developments for the future will be discussed in a further article.

JIGS, FIXTURES AND PRESS TOOLS MADE OF PLASTICS

THEIR SCOPE IN SHORT PRODUCTION RUNS

A conference on plastic tooling, organised by the Sheet and Strip Metal Users' Technical Association, was held at the headquarters of the Institution of Electrical Engineers, London, in October.

Mr. A. Keats, O.B.E., President of the Association, who opened the conference, said that whatever might be thought about the possibility of plastics replacing sheet metal for motor-car bodies and similar products, there was no doubt about the wide field for plastics in the manufacture of press tools, jigs and fixtures. Some applications of plastics to press tooling were still largely experimental, and the suitability of such tools for long production runs had not been fully tested, though runs of over 20,000 had been reported, and it was understood that in America certain types of plastic tool had been used for runs of up to 50,000. The possibilities in the short-run field appeared to be very great. Plastic tools lent themselves to drop-stamp, hydraulic and mechanical power-press work, and their great virtue was their cheapness. They might well revolutionise the production costs of certain components.

The President's opening remarks were followed by the reading of papers on various aspects of plastic tooling.

SUITABILITY OF PLASTICS FOR PRESS TOOLS

In a joint paper entitled " Some Experiments in the Suitability of Plastics for Press Tool Manufacture," Professor J. V. Connolly, Mr. P. K. Digby and Mr. W. J. Paul examined at length both the economic and technical aspects of the use of thermo-setting and thermo-plastic materials for drop-hammer work and for double-curvature panel drill jigs. Special tools were designed to isolate the variable parameters and their behaviour was studied with the aid of high-speed cine-photography. Many different plastics were studied, and the conclusion reached was that tool production is easier and cheaper with these materials than with zinc alloy. The time-cycle of production is also reduced by about 80 per cent., with a corresponding reduction in man-hours required.

It was found that Tenite Medium Hard was a good punch material. It had a life of over 1,000 components and the spring-back differed from that of a K.M. hard-alloy punch by less than one degree for all the tool shapes tested. Savings with the plastic material were approximately 87 per cent. cost, 84 per cent. man-hours and 81 per cent. time-cycle. The most satisfactory die material developed was manufactured from Araldite D. resin, glass fibre and French chalk. Limited tests with a Tenite Medium Hard punch gave satisfactory results for short runs, and longer runs could probably be made. The savings were: cost, 68·5 per cent.; man-hours, 86 per cent.

PLASTIC PRESS TOOLS FOR MOTOR VEHICLE PANELS

Mr. W. B. Kidd, in his paper on " The Use of Plastic Press Tools for the Production of Motor Vehicle Panels," said that vehicle panels often embody both concave and convex forms with well-defined beads usually following the panel contours. The usual method of production is with " Kirksite " zinc-base alloy dies. In certain circumstances this technique presented difficulties, and it appeared that a solution was possible if some tooling material could be found which would be easy to shape to the varying contours of a metal die, and yet would not flow hydraulically at pressures of 2 to 3 tons per square inch. The material would also have to be strong, resilient, and tough enough to form 18-s.w.g. sheet steel, and have reasonable wear resistance.

At the time when the author carried out his experiments two general types of plastic material were available; one could be melted and cast to shape, the other could be fabricated from blocks and shaped by heating. The latter appeared to be the most suitable. It could be bought in fairly large blocks and worked by ordinary woodworking technique. Final shaping could be done by heating the surface and pressing it on to the metal die.

The material chosen was an ethylene polymer known as polythene, or by the trade name of " Alkathene." It has a smooth, wax-like surface and weighs 57 lb. per cubic foot, which is slightly heavier than hard wood. Its impact strength is very high, and it has a compressive strength of 2½ to 3 tons per square inch. On thin sections this strength is considerably higher. Polythene is very resilient and would allow for limited variations in material thickness. It can be cut and worked by simple woodworking tools, and joints can be made by the application of heat, the joints having properties equal to those of the original material. By heating the surface to approximately 120 deg. C. it becomes soft enough to take an impression from a metal die, and when cold it can be used for metal forming.

Some experiments were carried out with this material before any large tools were made. The first experimental tool was a simple bending die for a " hat " section in 2-in. wide material. The tool consisted of a steel female bottom die and a top male die of plastic on a steel backing-plate. It was set up in a fly-press and 400 components of 18-s.w.g. and 16-s.w.g. steel were made. The clearance between the two parts of the tool was sufficient for 18-s.w.g. material, and it was hoped that the plastic would deform sufficiently to accommodate the thicker strip. In practice, it was found that the load required to deform the plastic was too great for the fly-press, and the top die was accordingly reduced in width. Later experiments with this type of tool showed that the plastic would deform to allow for gauge variation, but that greater press tonnages were needed, and an increase in wear took place. The worst damage done to the plastic was by the edges of the steel strip, which were slightly narrower than the die. They cut a series of ragged grooves in the surface of the plastic, but there was no interference with the operation of the tool.

The second tool, which was used on a larger fly-press, was of similar type but with radiused contours. The form of the top die was sawn roughly to shape and screwed to the steel backing plate. An electric fire was then placed on its side underneath the top die, and heat was applied to the surface of the plastic. After a few minutes the whole face was transparent to a depth of ⅛ in. to $\frac{3}{16}$ in., and the top die was then lowered into the bottom one and held there for about ten minutes. Surplus plastic which had been squeezed out was trimmed off with a wood chisel. The die was allowed to become completely cold, and it was then used to produce 500 parts from 16-s.w.g. material 2 in. wide, no deterioration taking place in the die. Parts of 10 s.w.g. were then made, and in spite of the gauge difference, 100 were produced successfully. Finally, ¼-in. strip was tried. The top die was shaped to allow more clearance, as the pressure available was insufficient to deform the plastic. Two or three press strokes were needed to produce a single component, and the plastic began to wear rapidly, the surface breaking away in small shreds. Other small dies were then made to see if the plastic would form sharply-defined edges on beads and swages. It was found that 400 to 500 parts could be made before the die surface had to be renewed.

This was done by heating the plastic face and pressing it on to the steel die.

A larger die was then made. It consisted of a "Kirksite" bottom block, cored for lightness, and a top die of plastic with a cast-iron backing plate cast to follow roughly the contours of the bottom die. The tool was designed for producing a radiator grill-plate. Wood screws were originally used to attach the plastic to the backing plate, but this proved unsatisfactory, and bolts, with their heads let into the plastic, were used instead. Fixing the bolts in the plastic was a simple procedure. The bolt heads were heated, pressed into the plastic and allowed to cool. To form the die the bottom block was mounted on the press bed and the plastic, which had been screwed in position on its backing plate, was mounted on the press ram. The plastic face was then heated and impressed on the bottom die.

A gas heating apparatus was used as a matter of convenience, though an electric element was found to be most successful provided that the whole area could be covered and the contours followed. The gas heater consisted of steel piping bent to follow the general contours of the die, and having small holes drilled in the sides. The gas and air supplies were adjustable so that flames from 2 in. down to $\frac{1}{16}$ in. could be produced. The heating pipes rested on the bottom die. The press ram had been "inched" to about 6 in. from the heat source, and the adjustment was set so that at the bottom of the 16-in. stroke the plastic would be $\frac{3}{8}$ in. to $\frac{1}{2}$ in. from the face of the die block. The remaining distance was to be taken up by the press-ram adjusting screws. Later experience showed that this method of setting the press was not the best, but in the early stages it was considered safer, as the ram-adjusting screw motors would cut out when the load became too great. After experience had been gained the adjustment of the ram was taken up first, and the press made a full stroke.

Correct heating of the plastic is important, and it was found that flames about $\frac{1}{2}$ in. long, with the heat source 2 in. to $2\frac{1}{2}$ in. away from the plastic surface, were best. When the edges of the plastic are transparent for about $\frac{1}{16}$ in. deep the impression can be made. It is vital that the plastic be allowed to cool while it is actually in contact with the bottom die, and if a number of impressions are made, cooling must be allowed for at each stage. Flash can best be removed while the plastic is hot.

The production of pressings with plastic dies presented no particular difficulty compared with conventional methods, but care had to be taken to see that the blanks had no sharp edges which would damage the plastic. No lubrication was needed. In practice, the sheets were oily, and it was thought that this might have some effect on the plastic, but no harmful effects were found, provided that the plastic surface was wiped occasionally, and after use. It is, of course, important that the plastic shall be perfectly clean when re-impressing dies.

Experience has shown that the number of pressings which can be made before the die needs re-facing depends on the sharp corners and on the importance of detail. If very sharp corners or sinking are required, 500 to 1,000 parts can be produced from 20 to 18 s.w.g. steel before re-surfacing is necessary. If the forms do not need to be very sharply defined, the life of the die is extended considerably.

ETHOXYLINE RESINS FOR TOOL MANUFACTURE

Ethoxyline resins were dealt with by Dr. K. Meyerhans in his paper "The Use of Ethoxyline Resins in Modern Tool Manufacture." Dr. Meyerhans said that the properties of ethoxyline resins included: setting at room temperature without application of pressure, setting without giving off volatile substances, setting without or with only very slight shrinkage, good adhesion to most materials, outstanding mechanical strength in the hardened state, and no corrosive effect on metals. They had extensive possibilities of filling with organic and inorganic, pulverised, fibrous and textile materials, and could be stored almost indefinitely, provided that the resin and setting agent were not mixed. Tools could be made from these resins by lamination or by casting.

The method most frequently used for making ethoxyline resin tools by lamination resembles the process already known in the preparation of polyester resins. A method which has proved satisfactory is to apply a thin, even layer of parting lacquer to the surface of a model by brush or spray-gun, and leave it to dry at room temperature or under infra-red radiation. This is followed by a homogeneous waxing in the form of a paste. When the wax layer has set it is polished with a wool rag. Two further coats of lacquer follow, and a further treatment with hard wax comes next. A resin layer, enriched with a fine organic filler or metal dust, is then brushed on or spread with a spatula, to prevent the glass fabric built into the laminated structure from appearing at the tool face. After $1\frac{1}{2}$ to 2 or more hours a glass cloth, cut to size on the original model and impregnated with resin, is pressed well down into the paste, care being taken to ensure intimate contact and exclusion of air. Finally, two or more additional layers of impregnated glass cloth are added, according to the size of the pattern. When the required layer thickness has been built up, it is set at room temperature for at least 14 hours. The proportion of glass fabric to resin is usually 1 to 1.

To ensure that the shell is dimensionally stable the laminated structure is reinforced. This can be done with a finely-meshed frame of aluminium or steel tubes; or synthetic or cardboard tubes, covered with glass fabric and ethoxyline resin, can be used instead of metal. The shell is joined to the frame with ethoxyline resin paste. Another method of reinforcing is to build glass-fabric laminated plates on the back of the shell. These plates follow the contours of the shell, and cross at intervals of 40 to 60 cm. The resulting square cells are filled to a depth of 5 to 10 cm. or more with ethoxyline resin to which specific light fillers are added.

Patterns and templates made by this process have several advantages. They are simple to make, as the resins can be applied at room temperature, without pressure, and the work can be done by unskilled labour. The patterns can be made to shape without further processing, or at least with very little processing, and they have great dimensional stability and mechanical strength. They are largely insensitive to acids, alkalis, fats, oils, greases and the usual solvents. They are not affected by humidity, and do not corrode.

DRAWING AND STAMPING DIES

Dies for stamping, drawing and similar work can be made by the lamination process, but as such tools require a very solid type of structure the building-up of layers is tedious. It is simpler, therefore, to cast them. A proprietary ethoxyline resin filler and hardener are available, which have negligible shrinkage while curing. Tools made of this material can be cast from plaster of Paris, wood or metal, as the curing is done at room temperature, without the application of pressure. Glass fabrics and steel components can be incorporated in the resin mass.

To produce a tool by the casting process the working surface is first prepared by spreading an ethoxyline paste on the pattern and mould walls to a thickness of at least 2 to 5 mm. The hollow space remaining is then filled with the casting material, ethoxyline resin, filler and hardener. The minimum layer thickness should be 100 mm. After curing at 15 to 20 deg. C. for at least 24 hours, the mould and pattern are removed. Economies in casting material can be effected by using core moulds, or by inserting metal blocks or chips and fragments of worn-out tools in the uncured resin mass. Metal or glass fabric reinforcements can be cast integrally with the resin. Tools of this kind are usually provided with an iron base plate, either by providing the plate with welded tie-bolts, or by screwing, in which case threaded bushes are moulded in the plastic. Metal parts which are not to be removed are derusted and degreased before embedding; metal parts to be removed are surface treated with silicone grease.

Ethoxyline resins can also be used to fix cutting punches to holding plates, instead of the usual soldering method. In such cases the punches can be hardened along their whole length. No softening occurs at the head, as the bonding cures at room temperature.

PLASTIC TOOLS OF POLYESTER RESINS

The paper entitled "The Development of Plastic Tools, with Particular Reference to the Use of Polyester Resins," by Mr. J. T. Maddison, had an introduction which pointed out the distinction between the two groups of plastics thermo-setting and thermo-plastic. Typical thermo-setting materials are the phenolformaldehyde resins and the recently-developed polyester and epoxy resins. Polyvinyl chloride, polythene and nylon are typical thermo-plastics. The thermo-plastics do not offer much scope for most tooling applications, which call for a permanently hard and rigid material. Consequently, the thermo-setting types of plastic, particularly phenolformaldehyde, polyester and epoxy resins are most used for tooling. Each of the materials is available as a liquid which is pourable, and can be hardened by a suitable catalyst. Polyester and epoxy resins harden without forming volatile materials, and moulding can be carried out with little or no pressure at room temperature.

Experience has shown that casting, i.e., the straight pouring of a filled polyester resin into a mould, is not suitable for producing press tools. In large masses the exothermic rise in temperature which occurs during hardening causes strains which cause cracking. To increase the mechanical strength and prevent cracking, attempts have been made to use a fibrous filler such as glass, but as the maximum amount of fibre which can be used while retaining a pourable mix is about 5 per cent., the fibres tend to bulk together. As a result, while parts of the tool are well reinforced, large resin-rich areas remain.

Tools can be produced by the dough-moulding process, using a material consisting of a homogeneous mixture of 40 per cent. polyester resin, 30 per cent. of chopped glass fibres and 30 per cent. of china clay, together with the necessary catalyst. A typical tool was made by placing a lead-covered pattern in a moulding box and placing the material on it by hand, tamping it down as it was introduced. The assembly was then cured in a press for several hours under a pressure of 10 to 15 lb. per square inch. This process has certain limitations, among which is the need for special equipment.

A method of tool construction has now been developed which appears to meet all the basic requirements. This is the lamination method, using a glass-fibre reinforcement. The reinforcement can be controlled to lie at the points of maximum stress; no special equipment is required; and the surface finish of the tool depends almost entirely upon that of the pattern or model. Tools made by this method consist of two parts, a surface skin of glass-fibre reinforced laminate, and a solid backing which forms the body of the tool. This backing contains chopped fibre mat as a reinforcement.

To produce the surface skin the mould, treated with a release agent, is painted with a layer of catalysed resin and a layer of fabric is pressed down into the resin. The process is repeated until the required number of layers has been built up. The body of the tool is built in two operations. To fill in the depressions behind the laminated surface skin the material is produced in an impregnating box, teased apart by hand and then packed into the depressions until the surface is level. The remaining height of the tool is built up by impregnating suitably-shaped layers of glass mat *in situ* in the moulding box.

Tools varying from 14 in. by 11 in. by 9 in. to 42 in. by 26 in. by 12 in. have been produced successfully in polyester resins. The accuracy

of reproduction is good, and the shrinkage is less than 0·001 in. per inch. Sharp radii, particularly on drawing edges, present a special problem, and the production of tools with such edges is not recommended.

PHENOLIC CASTING RESINS

The use of phenolic casting resin was dealt with by Dr. F. L. Gilbert, in his paper "Tooling with Phenolic Casting Resins for Sheet Metal Pressing." The paper dealt with one particular type of thermo-setting plastic, the phenol-formaldehyde resin. This can be produced in the form of a syrupy liquid which can be induced to harden when required by the addition of an accelerator. It is therefore possible to pour it into a mould, allow it to set, and obtain a tool which is an exact and permanent reproduction of the mould.

The accelerated resin sets hard. In order to obtain the most complete cure and the hardest resin it is recommended that a comparatively small quantity of accelerator should be used and the tool should be stove-cured. The cure must take place at less than 100 deg. C., and 80 deg. C. is the optimum temperature. If this is not possible, curing at 60 to 70 deg. C. is satisfactory, but it takes a little longer. Where stove curing is undesirable, or impossible because of a lack of facilities, it is possible to formulate a resin in which additional accelerator will cause hardening at room temperature. Nevertheless, all moulds should be stoved at the maximum permissible temperature up to 80 deg. C., while the resin itself, when poured, or immediately before the addition of the accelerator, should never be less than 21 deg. C. When a large tool is to be made a good deal of weight can be saved by coring-out part of the tool and filling the core with foamed resin. This is made from the same base resin but with a different catalyst and a foaming agent. An inert gas is evolved during the setting of the resin, which results in the production of an expanded resin of low specific gravity. The degree of foaming can be altered by adjusting the proportions of accelerator and foaming agent. A sufficiently rigid foam can be obtained with a specific gravity of 0·18. Foaming is carried out in a cubical box, and the block of foamed resin is cut into pieces of the required shape and size. These are suspended in the mould cavity, and resin is then poured round them to give the required 1½ in. or so of solid face. This technique is to be preferred where large changes in cross-section are found.

The most important preliminary to casting is the making of the mould itself, since the casting will be a faithful reproduction of the mould both in form and in accuracy. Moulds can be made from a variety of materials, but plaster is the usual one, as it is cheap and easily worked. The mould wall thickness should not be more than 2 in. and it should be reinforced with sisal, hemp or other fibrous material. The plaster must be thoroughly dried and several coats of parting lacquer should be applied to produce a smooth unbroken surface. Wood moulds should be made of good seasoned timber, and coated in the same way with parting lacquer. If metal moulds are used lacquer is still necessary if the metal is susceptible to attack by the acid accelerator.

In making the mix the only items of equipment needed are an acid-resisting container, a weighing machine and a wooden mixing stick. Ingredients should be weighed as accurately as possible. The resin can be added to the filler or the filler to the resin. It is usual to add the filler to the resin, either by hand or mechanically; however it is done it must be given a thorough mixing, and if possible the mixture should be allowed to stand for some hours to allow trapped air to escape. The accelerator is then added and the mixture is stirred for about 5 minutes. The mixture is then poured slowly and carefully into the mould. For hot-set resins the mould should be placed in a hot-air oven within 30 minutes of pouring and raised slowly to 60 to 80 deg. C. This temperature is then held for 10 to 20 hours, according to the size of the casting. Cold-set resins should be laid aside after pouring at a temperature of not less than 21 deg. C., and as much higher as possible. The resin will set firm in 30 minutes to 2 hours, but it must be left overnight to set fully.

Filled casting resins can be filed, sawn, drilled, tapped and ground without difficulty. A high polish can be obtained by sanding, buffing and polishing with Tripoli wax. Accidental damage can be repaired by using cold-set resin and accelerator mixture.

GLASS FIBRE FOR REINFORCING PLASTIC TOOLS

The paper entitled "Glass Fibre Reinforced Plastics for Press Tools, Jigs and Patterns," by Mr. A. M. Dobson, described the methods of manufacturing glass fibre and its conversion into various forms in which it can be used for plastic reinforcement. The fibre is made from glass "marbles," which are melted in a heated bushing. Molten glass issues from a number of holes in the base, and is attenuated either mechanically to produce a continuous filament, or by fast-moving streams of air or gas to produce a staple fibre. Staple fibre is normally converted into yarn by applying a twist, and then woven into cloth. Continuous filament can be converted into yarn, roving, chopped strands of ½-in., ¾-in. or 2-in., chopped strand mat, or diamond mat. Glass fibres can be used to reinforce many types of plastic, but the greatest use so far has been with the unsaturated polyester resins and more recently with the epoxy resins.

The moulding methods are various and can be summarised as follows. The "wet lay-up" method consists of preparing a male or female mould and applying a release agent to the surface. A thick coat of resin is then applied and the first layer of reinforcement is pressed down into the resin until it fits snugly on the mould surface. Further resin is then applied and the next layer of reinforcement is pressed into position. The process is repeated until the required thickness has been built up and the moulding is allowed to cure at room temperature. The rubber blanket technique involves the use of atmospheric pressure. Reinforcement and plastic are applied to the surface of a mould and the moulding is covered with a rubber blanket or a film of polyvinyl alcohol, which is clamped at the edges. The space between the blanket and the mould is then evacuated. Moulds are either steam heated or the whole assembly can be stoved.

The "hat-box" technique is similar to the preceding one, but air is blown into a rubber container to provide the necessary pressure on the plastic. The Neoprene plunger method employs a cast-aluminium female mould and a Neoprene male plunger. The plunger is so shaped that it first makes contact with the bottom of the female mould. Resin placed in the bottom of the mould is thus squeezed outwards and upwards. Sheets of reinforcement are cut to a size which will give an overlap of, say, 2 in. when the sheets have been driven home by the plunger. The sheets are laid by hand and covered with a piece of transparent plastic to act as a separator from the Neoprene plunger. Resin is poured into the centre of the mould, the sheets and film are held flat over the mould surface, and the plunger is driven home. The female mould is then heated to cure the resin. In the matched mould method reinforcement, usually mat, is laid on a heated male mould and resin is poured into the centre. The female mould is then driven home at a pressure of about 150 lb. per square inch. A "dough" consisting of chopped fibre strands, resin and filler can also be moulded in matched moulds, but if intricate shapes are involved pressures of up to 2,000 lb. per square inch may be necessary.

DRILLING

Glass-fibre reinforced plastics are ideal for drilling jigs. The mould can be an actual component, or it might be a master made from wood, plaster or any other suitable material. It should have a highly-polished surface and if it is of porous material such as wood or plaster it must be sealed with lacquer or wax. The pattern has then to be coated with a release agent, of which there are several available. They include waxes, polyvinyl alcohol and silicones; the resin manufacturers usually recommend a suitable one. The reinforcement usually employed is woven glass cloth, but where cost is important a cheaper form of reinforcement such as chopped strand mat can be used. The number of layers of cloth or other reinforcement will depend upon the size and shape of the article. A drill jig made by this method could be cured at room temperature by using suitable resins, but it is generally considered better to enclose the whole moulding in a bag and evacuate to produce an atmospheric pressure on the plastic of about 14 lb. per square inch. Curing should be done at 110 deg. to 130 deg. C. When cured the jig can be removed from its mould and metal bushes screwed or locked in position.

The use of glass-fibre reinforced plastics for press tools is new, and information on the subject is limited. The methods of manufacture are, however, fairly simple. A typical method is to make a master pattern of wood or plaster and fix it on to a base which is let into the bottom of a box. The mould surfaces are prepared and a layer of resin is applied. Chopped strands are then placed on the mould and a predetermined quantity of resin is poured on the top. A perforated cover is next placed on top of the chopped strands and forced into position by the application of a pressure of, say, 20 lb. per square inch. This forces the resin into the chopped strands and displaces air. Finally, the perforated plate is replaced by a solid one and pressure is applied and maintained until curing is complete. When the female tool has been made by the process described, it can be used as a former for making the male tool. Steel inserts can be placed in position during the "laying-up" and they become a permanent part of the tool after curing. Their use is advisable where sharp corners are involved. Damage occurring during the working life of the tool can be repaired by removing the damaged parts and adding a further layer of glass cloth and resin.

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A DRY BEARING

Plastic-Impregnated Bronze Matrix

A dry bearing having a coefficient of friction as low as that of a conventional lubricated bearing has been introduced by the Glacier Metal Company, Limited, of Alperton, Wembley, Middlesex. It is particularly suitable for applications where the presence of oil is undesirable, as in food and textile machinery. The bearing is made of the plastic polytetrafluoroethylene (PTFE) in conjunction with a porous bronze matrix. PTFE has a dry surface coefficient of friction of 0·05, but has a tendency to change shape without any externally applied forces. This disadvantage is overcome by use of the bronze matrix, which is impregnated with PTFE; the resulting material is bonded to a steel backing and employed in strip form. The bearing can be used where corrosive liquids would attack conventional bearing materials, since the plastic is chemically inert, and in ambient temperatures up to about 280 deg. C.

The load and speed capacities of the bearings are determined largely by the ability of the assembly, of which they form a part, to dissipate heat. In a test of over 1,000 hours with a load of 93 lb. per square inch and a speed of 126 ft. per minute the shaft wear was 0·0002 in. and the bush wear 0·0012 in. Many shaft materials can be used, but very soft materials and alloys high in copper should be avoided.

Standard bushes incorporating PTFE are made by the Glacier Metal Company in 38 sizes up to 2-in. bore and thrust washers in 18 sizes up to 2¼ in. bore.

CENTRAL RESEARCH DEPARTMENT OF MORGAN CRUCIBLE COMPANY

INVESTIGATING CARBON PRODUCTS AND REFRACTORIES

In a large company making a wide range of products, research necessarily covers many different fields, and to control and apply it efficiently it must be carefully co-ordinated. To achieve this the Morgan Crucible Company, Limited, Battersea Church-road, London, S.W.11, has established a Central Research Department which has taken over the duties formerly carried out by separate research units attached to other departments. The extent of the research performed by the new department is indicated by the company's products which include refractories, carbon brushes for electrical machines, lubricants, sintered-metal articles, electronic components and silicon-carbide heater rods; in addition to plumbago crucibles, paints and other carbon and graphite products.

Since their beginnings, nearly 100 years ago, as makers of clay-bonded plumbago crucibles, the Morgan Crucible Company have extended their interests into a remarkable variety of fields, and, while still retaining as their headquarters the original works in Battersea, now immensely expanded, they make their specialised products in a number of other works, spread over all the five Continents. In the manufacture of all of these products, the fruits of research and the application of scientific methods and appliances enter largely, and it was obviously desirable, therefore, that some degree of centralisation should be introduced into the organisation of the research activities of the company and their subsidiaries; though it was realised, at the same time, that any attempt to carry on their highly diversified manufacturing operations by any form of superimposed scientific "remote control" would certainly defeat its object.

In past years it was the practice for departments to have their own research facilities, but there were also central analytical laboratories, and a direct co-ordination of technical effort at the higher staff levels. After the war, however, it was decided to rationalise these activities by setting up at Battersea what is now the Central Research department, responsible, through a general manager, to a director; but, in view of the nature of much of the work, it was also decided that process and production control and development must continue to be organised on a departmental basis. The task of organising this new department is now completed.

The general manager is directly responsible for administration and for co-ordinating the work of the three groups into which his staff and their functions are divided. The Research Group covers the fields of physics, chemistry, high-temperature chemistry, mathematics, and the design and operation of pilot plants. The Engineering Services Group is concerned with engineering methods, instrumentation (including pyrometry) and the operation of the experimental kilns. Finally, there is the Scientific Services Group, which deals with chemical analysis, physical analysis, and the collection and diffusion of scientific information, including matters relating to patents, and the management of a central library.

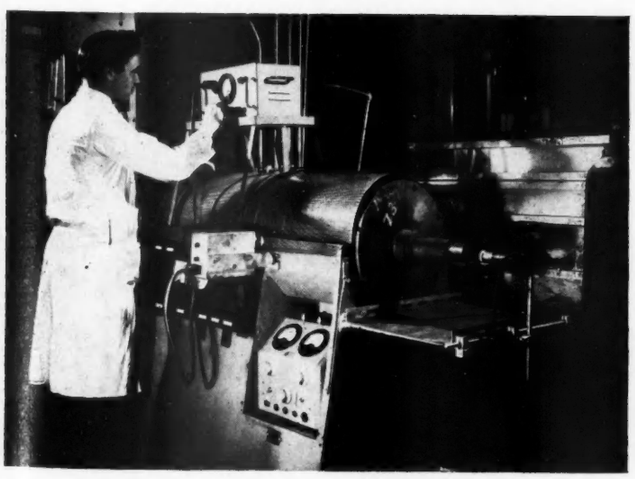
RESEARCH GROUP

The work of the Research Group is derived from three main sources, namely, the technical committees of the various company manufacturing groups, research and development contracts from such outside bodies as the Ministry of Supply, and investigations originating within the Central Research Department itself. At the present time, the first of these accounts for about 55 per cent. of the available effort, the second about 20 per cent., and the third about 10 per cent. The balance of about 15 per cent. represents day-to-day consultative services and inquiries which come in from the various development departments of the company's organisation.

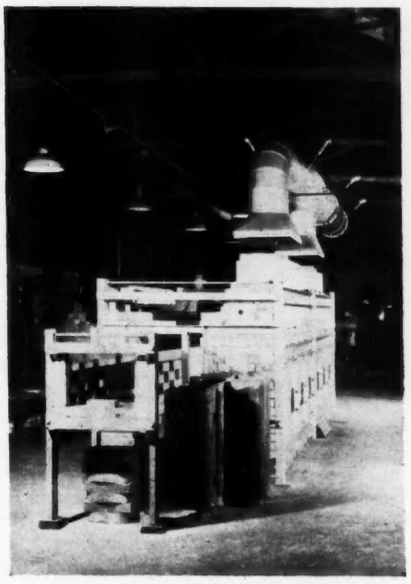
In the chemistry section, the work is mainly inorganic or physical chemistry. Typical subjects for investigation are the properties of silicon carbide, and especially its reactions with gases; the reactions which occur between the various constituents of graphite crucibles during works heat-treatments; and the oxidation of carbon and graphite. Studies have also been made, or are in progress, on the rheology of clays and of synthetic resins used in certain chemically-resistant cements. Radioactive isotopes are being used to study the possible formation of films by carbon brushes running on copper commutators, and investigations are proceeding into the formation of refractory coatings for carbon and graphite, and on materials for use in radio resistors and potentiometers.

HIGH-TEMPERATURE WORK

The high-temperature chemistry section is mainly concerned with chemical and metallurgical processes and reactions which occur at temperatures above about 1,500 deg. C.; a range that is of great importance to the carbon and refractory sides of the company's business, but about which there is not a great deal of published information. A carbon tube furnace used in high-temperature chemical research is shown below. The problems under investigation include the use of metal-ceramic components in engineering applications at high temperatures, the wetting properties of metals, and the development of refractory turbine blades.



A carbon tube furnace used in high-temperature chemical research. The chemistry section investigates the behaviour of carbon and refractory products and metal-ceramic components at high temperatures, often above 1,500 deg. C.



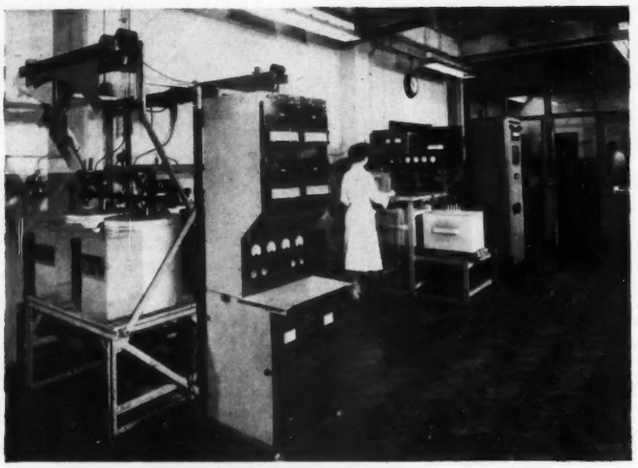
Experimental kiln for testing refractories under service conditions and for developing new kiln processes and firing techniques.

The activities of the physics section are also concerned with high-temperature work, as it was in this section that special tests and test-rigs were developed for determining the properties at elevated temperatures of refractories, metal-ceramics and carbon. The upper picture on the next page illustrates equipment for testing the mechanical strength of specimens at high temperatures. The electrical properties of silicon carbide are also receiving attention. Other subjects under examination are the particle-size analysis of powdered materials, the measurement of very high temperatures, the determination of the heat-transfer data required in the design of graphite heat-exchangers, and the fundamental physical factors which influence the functioning of carbon brushes.

STATISTICAL ANALYSIS

Typical of the work of the mathematics section is the design of controlled works experiments, and the statistical analysis of technical production data; the examination of experimental observations which might lead to improved methods of research or development; and the provision of simple working analogues for the use of the sales department in presenting technical details that are inherently difficult to express. Among the recent investigations undertaken by this section are research into the growth phenomena associated with certain of the metal-carbon products, and into the tool wear experienced in machining some carbon products.

Where research seems likely to lead to the development or production of new materials or processes, it is placed in the hands of the bench pilot-plant section, which is available to put into practice the ideas of the other research sections and so to assess their economic possibilities. The production of a new form of ultra-high-ohmic resistor, now on the market as the "Megistor," was developed in this section from experimental work done in the chemistry section. When the value of this work had been proved in the pilot stage, the process was passed over to the appropriate division of the company as workable and



Equipment for testing the mechanical strength of specimens at high temperatures. Electrical and other properties of materials are also studied by the physics section.

economically sound. Similarly, the section has developed a process for producing a special form of refractory support for catalysts.

ENGINEERING AND INSTRUMENTATION

The primary functions of the methods-engineering section are to meet the needs of the Central Research Department for all kinds of mechanical and electrical devices, to investigate any production problems which may arise in any of the Company's manufacturing groups, and to be prepared to advise on the latest production-engineering techniques. The practical side embraces everything from the most primitive temporary expedient to precision work of the highest quality; and the production problems can range from a simple modification of a jig to the design of a prototype machine or a revised layout of a shop. It is stated that 75 per cent. of the apparatus and equipment used in the Central Research Department has been made in this section.

Temperature control is probably the most important single factor in the many production processes carried on by the Morgan Crucible Company, and the care and maintenance of instruments, especially those for measuring and recording temperature, ranks high among the functions of the Central Research Department. The instrument section is formed in three divisions, dealing, respectively, with repairing and servicing, pyrometry, and electronics. The pyrometry service is run on what the firm describe as a " territorial " basis, each engineer on the staff of this division having a given " territory " within the works and being responsible for the instruments in that area. The equipment includes a standards room containing Wheatstone bridges, N.P.L. standard lamps, a dead-weight tester for pressure gauges, etc.

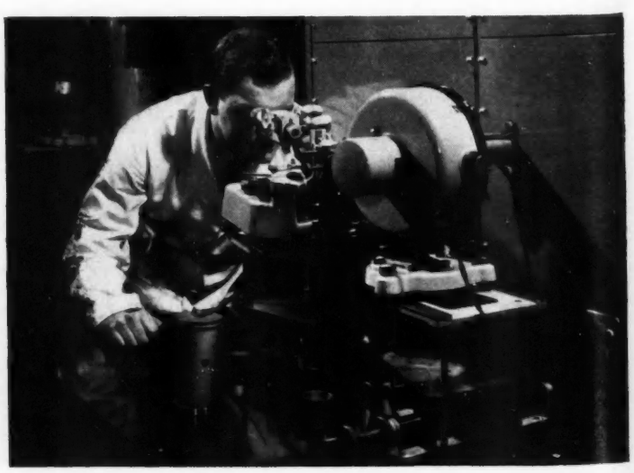
The remaining activity of the Engineering Group is the operation of the experimental kilns, one of which is shown at the top of the previous page, but in this their function is merely operative, the kilns being under the direct technical control of section leaders in the Research Group. They are used to test the firm's proprietary refractories under service conditions, to evolve new designs of kilns, and for the conduct of production trials on new kiln processes or on ware requiring new firing techniques to improve their quality.

ANALYSIS OF MATERIALS

In the Scientific Services Group, the analytical chemistry laboratory deals with routine or semi-routine analyses in their relation to process control, non-routine investigations on samples from all sources, the development of new methods, and the investigation of new analytical techniques. The physical-analysis laboratory is concerned with the examination of materials and products by physical methods, more especially microscopy, spectrography, and X-ray diffraction. An X-ray diffraction unit is illustrated below. The information section, as its name implies, collects, stores, records and disseminates technical and scientific information from all sources, and also stores and indexes the records of all research carried out by the Department, maintains a technical library, scrutinises the world's technical Press, and deals with the company's patent business. It may be remarked that both of the X-ray diffraction sets used in the physical analysis laboratory were constructed jointly by the joint efforts of the Scientific Services Group and the engineering methods section of the Engineering Group. This is typical of the way in which the various sections of the Central Research Laboratory work together.

The staff of the Central Research Department comprises a balanced team of professionally qualified physicists, engineers and chemists, with a due proportion of juniors in process of qualification, and of assistants who are not academically trained, but who can co-operate with intelligence in the many and varied tasks which arise. Where the research workers are concerned, it has been the deliberate policy of the company not to segregate their research workers in small teams, pursuing their objectives, as it were in separate cells, and largely unaware of each other's problems and activities. For that reason, it was decided to have a few large laboratories rather than many small ones, and each graduate member of the scientific staff normally has, at any given time, at least two projects in hand, often quite different in character. Moreover, the assistants are not attached to one graduate or project, but usually are assisting more than one of the graduate researchers. Liaison with the technical committees of the manufacturing groups is assured by representation of the Central Research Department on each committee, and by providing that the individual responsible for a project shall be able to report personally to the same committee.

The broad layout and guiding principles of the Central Research Department have been conditioned greatly by the rather exceptional character of the materials with which it has to deal. Some of them are natural products, but many are the unrefined products of other process industries, often complex, and frequently materials which have not been the subject of much scientific attention or inquiry. In many of the processes carried on in the works, too, the basic reactions are commonly incomplete, and are always difficult to study and measure; and often it is the case that the finished products are of such a kind that simulative service testing has only a limited usefulness. In planning their Central Research Department, therefore, the Board regarded scientific research and purely empirical technical development as complementary means of achieving progress, permanently allied and each likely to continue as an essential factor in the improvement and extension of the company's products.



The physical examination of materials and products is performed by such methods as microscopy, spectrography and X-ray diffraction. An X-ray diffraction unit is shown here.

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LUBRICATING OIL

Reduced Viscosity Variation with Rising Temperature

The viscosity of a new motor oil is claimed by its makers, Borlase, Field and Company, Limited, London, W.11, to be that of an S.A.E.-30 oil at engine running temperatures, but that of an S.A.E.-10 oil when cold. At starting it is light and will circulate easily, giving quick lubrication and protection to the vital parts of the engine, but on account of its high viscosity index it has the quality of a normal S.A.E.-30 oil when the engine is warm. Known as " Mohloob V.10/30 " oil, it reduces fuel consumption on starting and increases the life of battery and starter mechanisms.

It is an additive-treated oil which retains carbon in suspension and does not allow it to be deposited in the engine. It can only be used in new or reconditioned engines, because in older engines the additives would dissolve deposited carbons and cause blockages in the lubrication systems.

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We regret that on page 637, *ante*, it was stated that the Co-Co electric locomotives now undergoing trials on the French Railways between Valenciennes and Thionville were equipped with four 680-h.p. motors. Actually, the equipment consists of six 415-h.p. 600-volt motors, making the continuous rating of the locomotive 2,490 h.p.

STORING AND SUPPLYING SPARE PARTS

A NEW STORES FOR COMMERCIAL VEHICLES

To facilitate and expedite the supply of spare parts for A.E.C., Crossley, and Maudslay commercial motor vehicles, the group selling organisation for these three concerns, A.C.V. Sales, Limited, 50 Page-street, London, S.W.1, have just completed a special building at Southall, Middlesex, for the systematic storage and handling of such parts so that they can be readily supplied to those who need them. The building, which is already in use, was formally opened on Friday, November 5, by Lord Brabazon of Tara, G.B.E., M.C., P.C., Chairman of Associated Commercial Vehicles, Limited, and covers an area of about 58,000 sq. ft. Its construction and equipment have cost over £250,000.

ONE-WAY MOVEMENT

The primary aim in designing the building has been to confine all the main storage and packing to the ground floors and to avoid unnecessary handling of spares. The storage area is in one main block with wide gangways for mechanical transport between the bins. One of these gangways is shown in the upper illustration. All receipts enter this area and are moved in one direction towards the packing and dispatch area on the west side of the building at the end of which is the dispatch-bay wing. The packing bay is illustrated below.

The packing-case making and storage area, which is located in the receipts bay, is equipped with woodworking machines, and provided with electrically-heated and thermostatically-controlled dipping tanks for cleaning and protective treatment, and there is also a spraying plant for complete engines and other units which cannot be immersed.

The binning of the main stores was made to A.E.C. designs and specifications and was supplied and erected by the Steel Equipment Company, West Bromwich. It has been made of a standard height of 10 ft. 3 in., but the bins have been made of sufficient strength to support additional bins at the top to allow for future extensions. The shelves are in most cases adjustable in 2-in. steps and the vertical dividers are also adjustable. Special racks are provided for certain spares, such as valves, cardan shafts, spring leaves, exhaust pipes and differential and gearbox assemblies. The light-storage area, which is used for lightweight spares and valuable parts and can be shut off from the main store and offices if required, is equipped with mobile sliding bin units.

HANDLING AND TRANSPORTATION

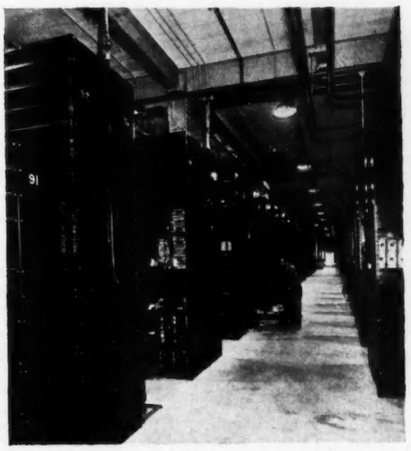
The handling of heavy stores and packing cases within the building is carried out by an interconnected system of electric span cranes and monorails supplied by Geo. W. King, Limited, Stevenage. The packing and dispatch bay is served by two 2-ton cranes of 30-ft. span, and the receiving bay by a 2-ton and a 1-ton crane both of 30-ft. span. The one-ton crane is interconnected with an electric monorail which serves the immersion tanks and also with a further one-ton 42-ft. span crane which covers the storage area for heavy components. This last mentioned crane is in communication with an additional monorail extending over the whole length of the dispatch bay, a distance of about 300 ft., so that heavy items can be delivered directly to their packing station or on to a road vehicle. For transportation inside the store, hand trucks and electrically-driven pedestrian-steered trucks are employed. Brush electric trucks are used externally.

LIGHTING

Electric power for heating and lighting is brought in at 6,600 volts from a ring main in Windmill-lane to a 500-kVA transformer substation inside the building, where it is stepped down to suitable voltages. A low-tension switchboard in the substation controls the distribution to all parts of the building. Fluorescent lighting is provided for the offices; tungsten lamps in special dispersive fittings are used in the first-floor store and for part of the storage space on the ground floor. In the main single-storey stores area tungsten lamps fitted at a high level are used for general illumination and low-level fittings with independent switching are provided for local lighting between the bins. The electrical installation includes amplifying and sound-reproducing equipment located in the reception office and connected to loud-speakers in the various stores and offices. There is also, of course, a comprehensive system of Post Office and internal telephones and the Lamson pneumatic tube system has been installed for the transmission of documents between the offices and stores.

THERMOSTATIC HEATING

Steam for heating is obtained from the boiler house of the A.E.C. factory, about a third of a mile away. The steam main runs partly in an underground duct and partly overhead, supplying some previously existing buildings on the way. In the new building, the heating installation is divided into three main runs, one of which serves a system of thermostatically-controlled overhead unit heaters, another supplying steam for hot-water service, while the third is used for the office installation. This is thermostatically controlled by means of an electrically-operated modulating valve the impulses for which are obtained from a regulating unit differentially controlled by both internal and external thermostats. The offices are heated by wall convectors which can be independently controlled. The construction of the steam main and heating installation was undertaken by the Brightside Foundry and Engineering Company, Limited, Sheffield. A complete sprinkler system for fire protection has been installed by Atlas Sprinklers, Limited, Swansea.



The gangways between the bins are wide to facilitate mechanical transport.

The site, with a frontage to Windmill-lane, was formerly a sand and gravel pit, and although this has been gradually filled in over a period of many years, about 250 concrete piles 30 ft. to 40 ft. in length were used in the foundations for the building which is of steel-framed brick construction. Red sand-faced bricks are used for the exterior with cream Colourcrete pointing, and the windows, which are continuous through both the ground and first floors, are framed in reconstructed Clipsham stone. A stone canopied main entrance has been constructed across the south-east corner. The building has been designed as a single-storey unit, but a double-storey block on the east elevation, giving an additional area of 18,000 sq. ft., has been provided for offices and is partly used for light storage. The ground floor is of 8-in. reinforced concrete with a Granolithic surface 2 in. in thickness and is capable of supporting a load of 5 tons per square foot. Two loading bays for the receipt and dispatch of stores have been built as wings to the main building.

The architects for the new building were H. W. Weedon, F.R.I.B.A., and Partners, Edgbaston, and the contractors, Gee, Walker and Slater, Limited, Park-lane, London, W.1. All services were designed and installed under the supervision of the works engineer's department, A.E.C., Limited, Southall.

General view of packing bay showing cases awaiting shipment. The stores are equipped with a pneumatic tube system for conveying documents, and with loud-speakers.

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HEAVY-DUTY OIL FOR TURBINE GEARING

In order to deal with the lubrication problems of highly loaded reduction gears for Naval turbines, C. C. Wakefield and Company, Limited, 46 Grosvenor-street, London, W.1, have developed a heavy duty oil known as " Perfecto LC." This complies with Admiralty specifications and has been tested in a destroyer. In tests on a 3¼-in. gear test machine, with the oil at 70 deg. C., the scuffing load on EN34 gears was four times that of OM 100 oil when running at 6,000 r.p.m. and twice at 2,000 r.p.m. The latter figure was confirmed by full-scale tests. Similar improvements were obtained when using EN 36 steel. The oil does not attack copper, is unaffected by water and complies entirely with the OM 100 specification for steam turbine oils.

MAINTAINING A CONSTANT PRESSURE DIFFERENTIAL

Combined Relief and Vent Valves for Aircraft Fuel Tanks

A new series of valves to maintain a constant differential between ambient and aircraft fuel-tank pressures at varying altitudes has been evolved by the Hymatic Engineering Company, Limited, Redditch, Worcestershire.

A typical unit, Hymatic RV22, consists of two relief valves working in opposition and arranged so that the air flow in either direction by-passes one valve and is pressure-relieved by the other. Positive pressure relief is through a spring-loaded poppet valve which maintains the tank pressure to within $\pm \frac{1}{2}$ lb. per square inch of the nominal setting for flows up to 12 cub. ft. per minute of free air. Inward venting is through a sensitive diaphragm valve, a pressure differential of only 0·05 lb. per square inch being required to initiate inward venting.

An 80-mesh filter that can be withdrawn for cleaning without tools and without disturbing the pipework is incorporated to protect the valve seats and prevent entry of foreign matter into the tank.

Relief pressure is normally adjustable from 4 lb. to 5·7 lb. per square inch, although these values may be altered to suit specific requirements. The unit will function within a temperature range of + 70 deg. C. to − 30 deg. C. The reseat pressure is 0·4 lb. per square inch below the blow-off pressure.

When the valve is used for its standard duty of relieving excessive pressures during a climb, and venting inwards during a dive to prevent tank collapse, a smaller reducing valve may be used for fuel-tank pressurisation on installations where the valve caters for engine fuel consumption only. The valve will also control the pressure on the air side of the diaphragm of a buffer tank fitted to prevent excessive pressure rise during refuelling as a result of the time lag between operation of the pressure switch and the actual shutting-off of the fuel supply.

Constructed chiefly from light alloy with sealing members of synthetic rubber resistant to aircraft fuels, the RV22 valve weighs only 0·68 lb. Overall dimensions are 3·84 in. high by 3 in. in diameter.

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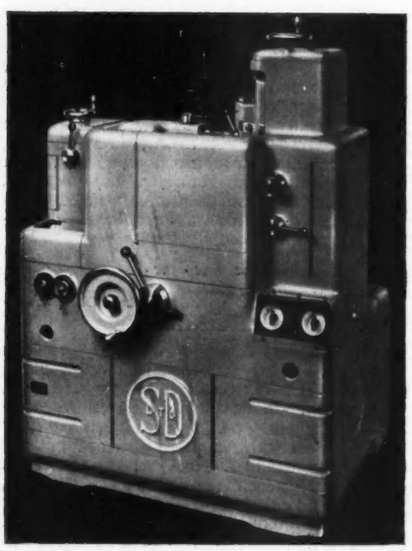

Spur gears up to 4 in. diameter and from 50 to 20 D.P. can be ground from pre-cut blanks or from the solid on the Stuart Davis "Heligrind" machine.

PRODUCTION GRINDING OF SPUR GEARS

GRINDING FROM THE SOLID OR PRE-CUT BLANKS

For grinding spur gears up to 4 in. diameter, Stuart Davis, Limited, Much Park-street, Coventry, have introduced the "Heligrind," a machine which operates on the principle of gear-tooth generation from the basic rack form, and uses a crush-formed grinding wheel. The machine is capable of finishing pre-cut gears or of generating complete gears from solid blanks, which can be of hardened material. It can also be used for the production of fine-pitch serrations and ratchets. The machine can grind gears up to a maximum of 4 in. diameter and from 50 to 20 diametral pitch. The maximum grinding length is 3 in. Limits, on a production basis, are to British Standard Specification Class A.1 precision ground tolerances. A typical production time is 9 minutes for grinding a 20-D.P. 40-tooth gear with a face-width of $\frac{3}{8}$ in., from a solid blank of hardened carbon steel.

CRUSH-FORMING THE GRINDING WHEEL

The wheel face is formed by a freely-rotating roller with annular grooves of the required pitch and form, which is traversed across the face of the wheel and fed into it as the forming proceeds. Operation of the forming mechanism is entirely automatic once it is set. The crushing roll is fed forward mechanically, traversed across the face of the wheel, retracted, returned to its starting position and fed forward again in a fully-automatic cycle. Pick-off gears mounted behind a hinged guard at the back of the crusher mechanism provide traverse rates for all the pitches within the capacity of the machine, and an adjustable sine bar is provided to enable the traverse rate to be set accurately to within 0·0001 in. There are no cams, and no mechanism to be adjusted other than the pick-off gears and the sine bar. A two-speed motor is provided for the grinding-wheel drive, and an electrical interlock ensures that grinding speed cannot be engaged when crushing is in progress.

The crushing roll is rigidly mounted, but easily accessible when the guard is removed, and can be changed quickly when necessary. For crush-forming a new grinding wheel a soft roll is used for roughing purposes, a hardened roll being substituted only when the last few passes across the wheel face are made. A crushing roll is estimated to give 20 to 30 crushes before reconditioning is necessary. It is the intention of the manufacturers of the machine to keep stocks of both hard and soft rolls so that a worn roll can be returned to their works and a new or reconditioned one dispatched by return. Once a wheel has been crushed to suit the pitch and form of the teeth being ground, the hard roll is left in position in the machine and is used for dressing the wheel as required. The intervals at which this becomes necessary will vary, of course, according to circumstances, but it is estimated that eight gears of 160 teeth can be ground between crushings. When this has to be done, it is only necessary to switch over to slow speed on the grinding head and engage the crushing mechanism. The form of the wheel face can then be re-crushed in about 3 minutes.

AUTOMATIC GRINDING CYCLE

The grinding wheel is carried on lubricated flat and V-slides, and is V-belt driven from a motor housed in the base of the machine. Crushing and grinding speeds are selected by a rotary switch at the front of the machine. The V-belt pulleys are on taper shafts, and can be changed to give different grinding speeds as required, an extractor being provided to facilitate the change-over.

The work is mounted on a mandrel between vertical centres, and is fed automatically in an upward direction as grinding proceeds. It is rotated simultaneously and the grinding wheel is fed forwards, so that at the end of the vertical stroke of the work-holding head the gear is ground to finished size. The grinding head is then automatically tripped-out and returned to its starting position. A specially-designed drive to the work-holding head eliminates backlash, and ensures that the work is driven smoothly and positively. Variation of work speed is provided for by pick-off gears in the side of the machine, seven feeds being available. A side control enables pre-cut work to be aligned accurately with the wheel.

The machine is provided with grouped controls, all of which are accessible from the front. Lubrication is by oil-bath or drip-feed, a mechanical gear-pump circulating oil under the control of needle vavles. Coolant is stored in a tank in the base of the machine and is circulated by a pump with a capacity of 6 gallons a minute to the grinding wheel. A directional valve over the wheel enables coolant to be directed to either the grinding or the crushing position as required. Baffles and filters are provided in the tank, which is mounted on castors. The pump motor can be disconnected by removing an interlocked plug, and the complete tank can then be wheeled out for cleaning and maintenance. Electrical equipment is housed in the base of the machine behind removable panels, and sockets are provided for 25-volt main lighting and 12-volt lighting for adjusting the crusher roll.

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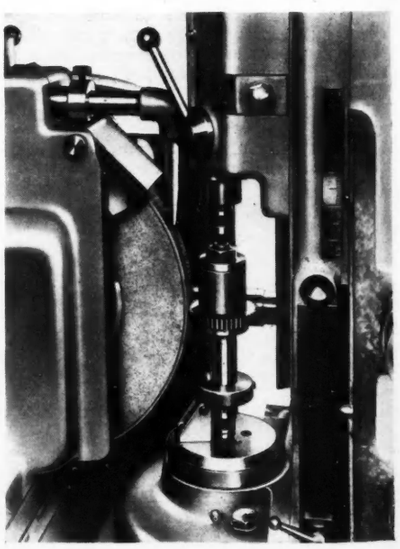
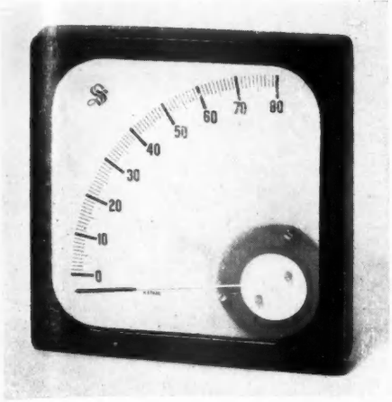
FILM OF DOMESTIC GENERATOR SETS

A 20-minute film has been produced by the Big Six Film Unit, 35 Endell-street, London, W.C.2, concerning the "Brabo" generating sets made by J. and H. McLaren, Limited, Airedale Works, Leeds 10. The film demonstrates the domestic uses of those sets, which range from $1\frac{1}{2}$ to 25 kW in size, in locations where a mains supply of electricity is not available. Sound tracks are being prepared in various languages so that the film can be shown in places abroad.



Work to be ground is mounted vertically on a mandrel between centres and the grinding cycle is automatic.



By mounting the movement in the corner of the case, an increased length of scale can be obtained while keeping the case to small dimensions.

COMPACT ELECTRIC METERS

Measuring Instruments (Pullin), Limited, Winchester-street, London, W.3, have recently introduced a meter which has a large scale but only occupies a comparatively small space. As will be seen from the illustration, this is achieved by mounting the movement in one corner of the square case and so giving the needle a 90-deg. arc of travel.

The dial of the instrument is made of unbacked translucent material which allows the meter to be illuminated by a back light. The case is of cast aluminium finished in black. Models are available for ammeters or voltmeters with a moving-coil movement. Sensitivity can be from one milliampere upwards, and a rectifier can be incorporated when required for use on alternating current.

* * *

PORTABLE SHEET-METAL CUTTING TOOLS

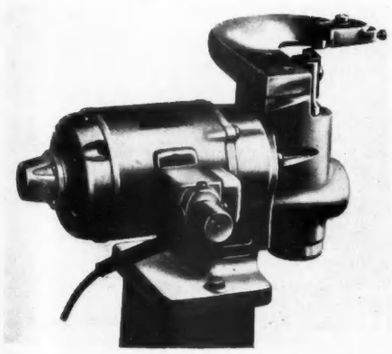
A new range of Trumpf portable shearing and nibbling machines and a rip saw have been introduced by F. J. Edwards, Limited, 359-361 Euston-road, London, N.W.1. The machines are driven by small electric and air motors and can follow a variety of contours including small-radius curves and straight through cuts in sheet metal. To enable them to be handled with ease, these machines have been kept as light as possible.

With most of the models the fan-cooled motor is enclosed within the gripping section of the machine body, and in the other designs an independent handle is fitted.

The range of these tools includes shears with cutting capacities from 0·065 in. to 0·18 in. thick sheet metal, and models with C-shaped blade carriers for trimming parts of pipes made from heavy-gauge sheet. The blade carriers fitted can have their cutting blades set in line with, or at right-angles to the motor-shaft axis. There are also pneumatically-operated hand shears which can be connected to the airline usually fitted in workshops. These are suitable for cutting sheet up to 1 in. thick, and can also be arranged with the cutting direction in-line with, or at right-angles to the motor axis. The nibbling machines and rip saws will cut metal up to 0·08 in. thick.

The bench type of shears which are illustrated are said to be particularly suitable for continuous operation. They can be mounted on any strong workbench or on a pedestal fabricated from sheet metal of the type shown in the illustration.

Models in this range of shears will cut sheet metal of 25 to 32 tons per square inch tensile strength in thicknesses of 0·14 in. and 0·18 in. The motors for these shears use alternating current, and the motor of the model in the illustration is provided with a coupling for flexible shafts, which may be used for driving curved shears for free-hand cutting sheet metal up to 0·08 in. thick. The shaft can also be employed with sanding, brushing and polishing equipment.



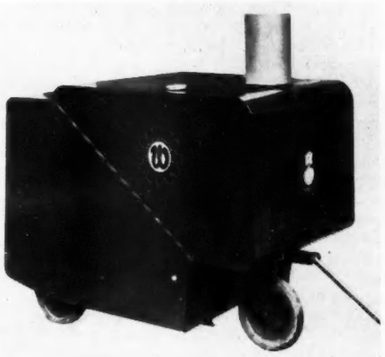
Pillar-mounted version of a new range of sheet-metal shearing tools. This model is said to be suitable for continuous operation.

* * *

MOBILE STEAM CLEANING PLANT

Oil-Burner Heating System

A new type of steam cleaning machine incorporating features which, it is stated, have not been used in this country, has been introduced by Wickman Industrial Equipment, Limited, a subsidiary of D. Wickman and Company, Limited, Ware, Hertfordshire. It is a high-pressure cleaner suitable for continuous operation with the minimum of maintenance. The design is based on experience gained from the German "Thermikus" machine in which the problem of scaling is said to have been reduced.



High-pressure steam cleaning machine.

An electrically-driven centrifugal pump gives a cold-water pressure of up to 150 lb. per square inch and ensures a full working pressure to either one or two jets. Lengths of steam hose up to 120-ft. per gun are fitted. One of the cleaner's main features is the rotary cup burner which uses either Diesel oil or paraffin and is adjustable to any temperature up to 165 deg. C. The fuel consumption is approximately 1½ gallons per hour for maximum performance. All the electrical fittings are standard and can be adapted to suit requirements. Safety devices are also fitted to protect the machine. The operating controls are grouped together on a single panel. The chassis is mounted on three wheels which are fitted with pneumatic rubber tyres, and the front wheel is coupled to the towbar and arranged to give a castoring action. The complete machine is housed within a sheet-metal casing where the fitter caps and exhaust nozzle are mounted.

Among the other mobile models in the range of steam cleaners introduced by this company is a light-duty machine designed to burn waste oil, and a steam-assisted machine which uses surplus steam from the factory heating system or other sources.

* * *

TRUCK BRAKE GEAR

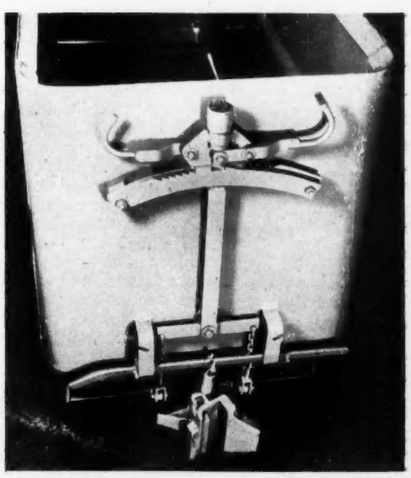
Operation from Either Side of Mine Car

Depending upon the arrangements for handling rolling stock it is sometimes an advantage to be able to apply parking brakes from one side of a truck and to release them from the other side without risk to the operators. A simple form of brake operating gear with this feature, developed primarily for use with mine cars, has been designed and put into production by Distington Engineering Company, Limited, Workington, Cumberland, and is shown in the illustration below.

Known as "Sindex," the gear consists of a lever, in the form of an inverted T, which can be moved on a pivot attached to the end of the car body, so exerting a pull at either end of the cross member. The ends of the cross member can be connected to almost any conventional arrangement of brake rigging beneath the car. Brakes can therefore be applied to any combination of the mine-car wheels according to the design of rigging selected.

The upper part of the inverted T-lever moves between two arc-shaped racks attached to the car body, and is fitted with two lugs, a double pawl, a coil spring and housing, and two hand levers. The double pawl engages in one rack or the other according to the direction in which the T-lever is pulled, and is held in engagement by a coil spring under compression within a cylindrical housing. On each of the lugs on the T-lever a hand lever is pivoted, and both hand levers are connected to the double pawl.

To apply the car brakes it is necessary only to pull either hand lever and the brakes will remain applied by the engagement of the pawl in one or other of the racks. To release the brakes a downward pull is exerted on either hand lever; the pawl is therefore lifted and the T-lever may be returned to its neutral position. It is therefore possible to release the brakes from either side of the car, irrespective of the side from which they have been applied, without inserting more than a hand and forearm between two adjacent car bodies.

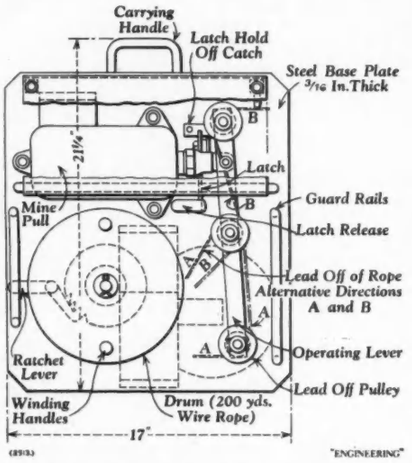


Truck brake gear enabling parking brakes to be applied and released from either side of truck without risk to the operator.

WIRE-OPERATED SWITCH WITH AUDIBLE SIGNAL

A mechanically-operated signalling and control unit has been produced by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, which is primarily designed for use with coal-face conveyors but has other possible uses. A drawing of the unit is shown below.

When the wire is pulled, the operating lever is rotated clockwise and the lower end rings a gong while the upper end operates the spindle of



By pulling the operating wire, the bell is sounded and the control circuit broken. The latter is not restored until the release catch is operated, though the bell can meanwhile be rung.

the " mine pull " and makes or breaks the micro-switches within the flameproof housing. After one operation, the lock-out latch will keep the control circuit locked out until the release lever is operated, although the gong will continue to sound each time the wire is pulled. A rubber shroud prevents the ingress of coal dust to the spindle or switches.

The pull wire can be taken round the pulleys on the operating arm so that it can be lead in either direction from the unit. The drum can accommodate approximately 200 yards of ¼-in. wire, allowing the unit to be operated up to this distance. The ratchet has 36 teeth which allows close adjustment of the wire tension.

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TRANSLUCENT PLASTIC ROOFING SHEETS

Two new corrugated glass-fibre sheetings, suitable for roof and ceiling lights, have been developed and are to be marketed by Saro Laminated Wood Products Limited, 45 Parliament-street, London, S.W.1, of the Saunders-Roe group of companies. The two sheetings, " Saropane" and " Sarolite," comprise layers of glass reinforcement bonded together with a low-pressure resin —a polyester. They differ in that Saropane is reinforced with " chopped strand mat "—short lengths of glass-fibre laid random—so giving a material that is almost transparent and with a low light-diffusion factor; on the other hand, Sarolite contains a woven glass-fibre of regular pattern so providing maximum light diffusion.

The sheets are made to match a large number of corrugated and trough-section roofing sheets; Saropane is available in two thicknesses of $\frac{1}{16}$ in. and $\frac{1}{8}$ in., Sarolite in $\frac{1}{16}$-in. thick sheets only. Both materials can be worked with ordinary tools, drilled or nailed, without risk of splitting, and being chemically inert have a high resistance to corrosion and to fire. As normally manufactured the sheets are water-white, but both can be supplied in colour.

BAND-SAWING AND FILING OF EXTRUSION DIES

TWO LARGE AMERICAN MACHINES

In the Lafayette, Indiana, plant of the Aluminium Company of America, light-alloy sections are produced in a 14,000-ton extrusion press and stress-conditioned in a 3,000,000-lb. stretching machine. Both these machines are claimed to be the largest of their kind in the world. To machine and finish the die apertures, and for other maintenance work in connection with the two production machines, the DoALL Company, Des Plaines, Illinois, U.S.A., have supplied a band saw and a filing machine which are also claimed to be the largest of their kind.

REMOTE-CONTROLLED BAND SAW

The machine for cutting the die apertures is a DoALL Contour-matic band saw which will cut any material up to 26 in. thick and weighing not more than 10 tons. Straight or contour lines, including circles, can be cut. The machine has a working area of 52 in. by 52 in. by 26 in. thick. It is 15 ft. 10 in. high, 21 ft. 6 in. long and 17 ft. wide, and weighs 8 tons.

A compound work-table, on hand-scraped V-beds, is mounted on a fabricated steel circular frame. The work-table is in two parts, mounted one above the other, and each part is individually motor-driven. The two parts of the table always move at 90 deg. to each other, but rotate together over the circular frame. The work is thus fed directly into the saw band for straight cuts and at a tangent for contour cuts.

The 40-ft. long saw band is mounted in a fabricated frame, which is of caliper form, to bring the working part of the saw to the centre of the work-table, and the saw band is carried by four rubber-tyred wheels each 26 in. diameter. The rubber faces are replaceable. Saws from $\frac{3}{32}$ in. to 1½ in. wide can be accommodated. The drive is from a 3-h.p. hinge-mounted motor with variable-speed pulley assembly, variable-speed belts and two-speed transmission. Band speed is hydraulically controlled and is infinitely variable from 50 ft. to 2,000 ft. per minite. Hydraulic band tracking on three of the four wheels is provided and the band tension is applied hydraulically. Tension is infinitely variable within the limits of maximum and minimum blade widths. Adjustable-insert type saw guides are fitted, with roller bearing back-up and a saw guide post having a hydraulically-controlled vertical movement of 28 in. An automatic saw welder and annealer is built into the machine.

The machine is controlled from a suspended station having an electrically-powered 28 in. vertical movement and a 90-deg. horizontal rotation. From this control station a seated operator, viewing the work through a periscope, controls the hydraulic and electric power electronically to steer the work into the saw. The table motion is independently controlled by push-buttons giving speeds of 16 in., 2 in., and ¼ in. per minute. Table feed is variable from $\frac{1}{16}$ in. to 32 in. per minute in three speed ranges. The rotary motion is infinitely variable from 0 to ¾ r.p.m.

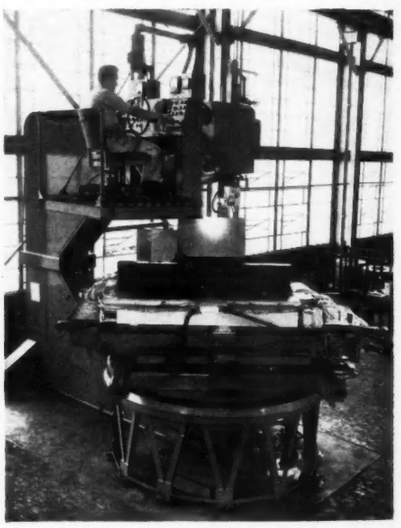
Pressure-fed, adjustable, metered lubrication is provided on the slide-ways. Coolant is supplied to the top of the work-piece through a control valve on the upper post and returns to a catch-pan and reservoir. Compressed air is used to remove chips from the work.

DIE FILING

The DoALL die filer employs a reciprocating file and can deal with dies up to 19 in. thick. It is of all-fabricated construction with a pedestal, arm and a yoke or filing head forming a pantograph. Dies are accommodated on a stationary work-table capable of carrying 5 tons, which can be tilted to a maximum of 5 deg. in any direction by means of built-in levelling devices. An operator seated at the front of the machine guides the pantograph filing head by means of two handles. The working area is 30 in. diameter and the throat dimension is 38 in.

Adaptors are supplied which will carry files from 9 in. to 23 in. long, in increments of 1 in.; ½ in. is required at each end for clamping. The stroke is variable from 2 in. to 9 in. in length, and the speed range is from 161 to 350 strokes a minute. Length of stroke is set manually by adjusting the crank throw, and the speed is controlled through a " Speedmaster " variable-speed gear driven by a 2-h.p. motor. A speed indicator on the front of the machine enables the stroke speed to be read directly.

Anti-friction and Oilite bearings are employed throughout the machine. A compressed-air jet taking air from the shop air-line is used to remove chips from the work.



The DoALL Contour-matic band saw has a compound work-table, electronically controlled by an operator who is seated above it and views the work through a periscope.

The filing machine has a pantograph-mounted filing head which is manually guided from in front of the machine.

The Paraminor washer has a hand-operated pump capable of delivering cleaning fluid at a rate of over 300 gallons per hour at a pressure of 20 lb. per square inch. The fluid capacity of the sump is 2 gallons.

WASHING MACHINE FOR SMALL COMPONENTS

Designed to meet the need for a small, compact and efficient parts-washing machine, the De Laval Paraminor—a development of the larger and well-known Parawash equipment—has been introduced by the Alfa-Laval Company, Limited, Great West-road, Brentford, Middlesex.

The Paraminor is of strongly welded steel construction and incorporates an efficient hand-operated pump of simple design capable of delivering at a rate of over 300 gallons per hour at a pressure of 20 lb. per square inch. A specially designed multiple-point jet head can be adjusted for fine or coarse sprays or for a solid jet.

An effective easily-cleaned filter is fitted; filter medium replacement costs are only a few shillings yearly. The sump has capacity for 2 gallons of cleaning fluid. The complete unit measures 15 in. wide, 19 in. deep and 23 in. high and can be placed on any bench or tool locker without fixing; no electricity, gas or water is required.

The Paraminor is designed for a cold cleanser, paraffin or white spirit, but it can also be used for oiling new parts before storage or assembly or for coating parts with rust preventive, etc.

In the machine shop the Paraminor can be employed for cleaning turned parts, gears, etc., of swarf and oil between operations, or before inspection or storage; and in the fitting shop for washing bearings, etc., before assembly, cleaning components for inspection and removing rust preventives from new parts.

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SELF-EXCITING SELF-REGULATING ALTERNATORS

The A.E.G. Electric Company, Limited, 131 Victoria-street, London, S.W.1, have now added to their range of alternators self-exciting self-regulating machines with outputs up to 20 kVA. On the majority of private requirements which work at unity power factor the voltage is maintained within $\pm 2\frac{1}{2}$ per cent. Machines with ratings above 3 kVA can handle power factors down to 0·95, but for smaller power factors the regulation drops to $\pm$ 6 per cent.

Models are available for two-wire single-phase, three-wire three-phase or four-wire three-phase supplies and for voltages up to 440 at 50 cycles. Normal running speed is 1,500 r.p.m.

PEAT-FIRED POWER STATIONS

OPERATING AND MAINTENANCE EXPERIENCE IN IRELAND

A paper which was read before the Institute of Fuel on Thursday, November 25, by Mr. W. Cronin and Mr. J. F. Lang, described the experience gained and the combustion technique employed with sod-peat at the Portarlington and Allenwood stations in Ireland.*

This fuel consisted of irregularly shaped sods varying from 18 in. in length to fines which would pass a $\frac{1}{8}$-in. sieve. The time taken for burning was very different and the maintenance of a uniform fire bed difficult. The moisture content varied from 20 to 50 per cent. In a load with an average moisture content of 40 per cent. particular sods might contain as much as 65 per cent. or as little as 25 per cent. There was also considerable variation in the fines, especially where the fuel had been loaded in the rain or mechanical loaders had been employed to scrap the bog surface. Dry fines tended to blow away and burn in suspension leaving holes for the admission of excess air through the grate. If wet they tended to form an impenetrable mass and move down the grate in a smouldering condition, eventually passing unburnt into the ash pit.

Anhydrous peat was a very consistent fuel with approximate analysis of 3·2 per cent. ash, 67·6 per cent. volatile matter, and 29·2 per cent. carbon. The ash contained 47·26 per cent. of lime, 18·17 per cent. of silica and 11·69 per cent. of iron oxide with smaller quantities of magnesia, sulphate, alumina and other compounds.

COMBUSTION METHODS

The firing techniques employed varied considerably with the moisture content and the density of the peat. In order to eliminate danger of fire and to prevent the volatiles being driven off at too early a stage, the peat with less than 32 per cent. moisture was only dried by direct radiation through the fire door. To protect the grate from overheating, due to the low ash content, the live fuel was run right back to the dumping bars, it being found that the ashpit losses were slight. Secondary air, which was normally admitted from the front only, was important owing to the highly volatile nature of the fuel, which produced a long flame as well as stratification in the gases rising from the grate. Unless therefore adequate turbulence could be created losses due to incompletely burnt gases were likely to arise.

With peat having a moisture content of 40 per cent. the principal problem was to maintain the ignition. The ignition line had, in fact, to be kept well forward if the loss of fire was to be avoided. Fires therefore tended to be shorter and the fuel bed thickness from 24 to 30 in., with correspondingly reduced grate speeds. The pre-heated drying air at a temperature of 220 deg. to 300 deg. F. was passed through the peat shaft. An alternative was to create an artificial arch of flame over the back of the fuel bed by using front and rear secondary air in certain proportions.

OPERATING DIFFICULTIES

One of the greatest problems in operating peat-fired boilers was the maintenance of a high thermal efficiency during normal service. During the official acceptance tests at Portarlington the boiler efficiency at the normal load of 120,000 lb. per hour was 81 per cent., based on the gross calorific value of the fuel. The moisture content of the peat was 27·6 per cent. and the "radiation and unaccounted" losses 2 per cent. In the course of subsequent normal operation, however, the weekly average efficiencies were rarely more than 72 per cent. and were frequently as low as 60 per cent. It was found that the "radiation and unaccounted" loss figure was usually in excess of 10 per cent. and although various firing techniques were tried no tangible improvement was obtained.

During the acceptance tests on the Allenwood boilers a thermal efficiency of 76 per cent. was reached with fuel of a moisture content of 30·2 per cent. The "radiation and unaccounted" losses were 6·7 per cent., which was outside the limit which would normally be accepted. Investigations failed to explain even a fraction of the heat losses, although an interesting feature was the presence of 23 per cent. of ammonium sulphate on the air heater-surfaces.

In March, 1954, it was decided to carry out a series of tests on one boiler at Portarlington using differing firing techniques and fuel of a moisture content higher than that employed during the official acceptance test. Particular attention was paid to measuring and testing methods (of which full details are given in the paper) and the possible errors from all sources were estimated. As a result, it was found that for fuels with 44·9 per cent., 39·0 per cent., and 38·6 per cent. moisture contents the thermal efficiencies were 63 per cent., 67 per cent., and 70·4 per cent., respectively; the corresponding "radiation and unaccounted" losses being 12·2 per cent., 12 per cent., and 10·4 per cent. There was, however, no satisfactory explanation of these high figures.

Investigations were now being carried out into the possible presence of unsaturated hydrocarbons, such as ethylene, as it was clear that a considerable amount of research would have to be conducted into the combustion of peat before final firing techniques and furnace designs could be adopted.

MAINTENANCE AND DESIGN PROBLEMS

The largest single item on the maintenance bill for peat-fired boilers was the travelling grate, owing to the low ash content of the fuel, the fineness of the fused ash and the excessive pressure of the fuel in the shaft on the front of the grate. Now, however, that many of the teething troubles had been overcome it might be assumed that maintenance on these peat-fired boilers would not be heavier than with similar units which were coal-fired.

From the point of view of design certain modifications would appear to be desirable. The evaporation tube banks should be removed from the furnace proper and a flame path of 40 to 50 ft. used before the gas passes were restricted by water-carrying tubes. A long back arch should be incorporated to shield the back of the grate from flame radiation and to assist the burning off at the back of the grate of peat which was abnormally wet.

ECONOMIC RESULTS

The economic production of steam from sod-peat-fired boilers had proved practicable. The fuel cost per kilowatt-hour generated during 1953-54 was 0·72*d.* at Portarlington and 0·77*d.* at Allenwood, compared with an average of 0·75*d.* at all the thermal generating stations. Sod-peat as a fuel had, however, serious inherent defects, including lack of uniformity and unwieldiness in size and variation in density and moisture content. It was unnecessarily expensive due to the labour required in winning, and stoker firing limited the available boiler output to about 200,000 lb. per hour if the size of the grates were not to become unwieldy. It was for these reasons that the development of pulverised peat-fired boilers was being considered. Experiments that had been made in this field showed that with suitable grinding and drying milled peat could be efficiently burnt, although there was a greater risk of explosion, and transport and handling were major problems. The Ferbane station was, however, to be equipped with three 220,000-lb. pulverised-fuel boilers.

* See ENGINEERING, vol. 171, page 389 (1951).

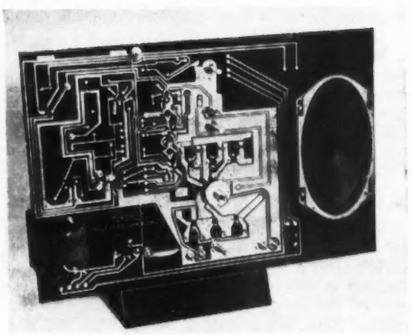
ELECTRIC CIRCUITS PRODUCED BY ETCHING

A method of reproducing wiring circuits for electronic and radio equipment by etching copper-foil sheets bonded to an insulating base has been developed by Millett, Levens (Engravers) Limited, Whadcoat-street, Finsbury Park, London, N.4. An important feature of the process, which is known as " Plasmet," is the effectiveness of the bond between the copper foil and the plastic base.

Foil 0·0015 in. thick is applied to the insulating base and on it is reproduced by normal chemical engraving methods the conductor layout required; the unwanted copper is then removed by an ultrasonic process, leaving the desired circuit on the insulating material. Holes are then stamped for the valve holders and component leads.

In general, components can be connected in the circuit most rapidly by dipping the copper side of the composite plate into hot solder, and an example of a radio chassis produced in this way is shown in the accompanying illustration.

This technique has been developed to increase the speed and economy of assembling electronic circuits. Etched inductors have already been made and it is believed that resistors and capacitors may in the future be produced by the same method. The copper-insulator material has considerable mechanical strength and the makers consider that it is sufficiently rigid alone to support equipment; no additional chassis would therefore be required. The conducting capacity of the copper strips is limited by their width, but strips $\frac{1}{8}$ in. wide have performed satisfactorily when carrying a current of approximately 5 amperes.



An etched electric circuit. Wiring layouts for radio and electronic equipment are reproduced by etching copper-foil sheets bonded to an insulating base.

Plasmet etched circuits were exhibited at the recent London Regional Display of the Engineering Industries Association.

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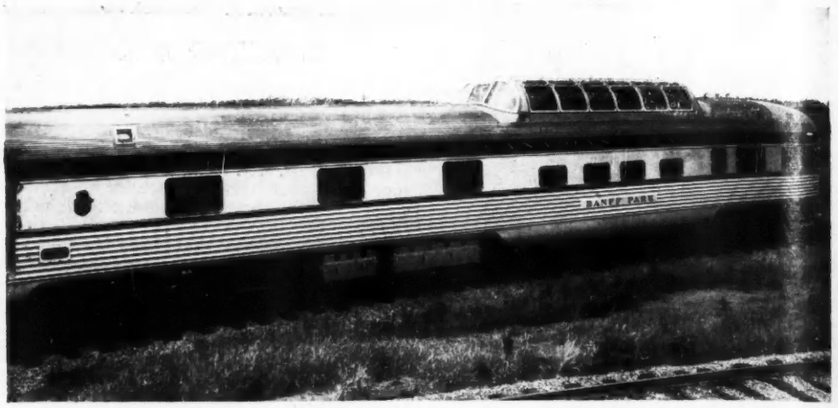
MAZDA LIGHTING SHOWROOM

The British Thomson-Houston Company, Limited, have now opened a showroom at Crown House, Aldwych, London, W.C.2, for the purpose of demonstrating Mazda lamps and lighting fittings. The opening commemorates the partnership of Thomson and Houston which began 75 years ago. It is also 75 years since Edison produced his first electric lamp in America shortly after Swan had in England.

The first exhibition at the showroom is of lighting through the ages, and particularly of the development of the electric lamp since 1879. The oldest exhibit is a Phœnician oil lamp dated about 1500 B.C., and the latest are a 1-kW mercury vapour discharge lamp and a 10-kW tungsten filament projector lamp. The manufacture of the discharge lamps was described in ENGINEERING, vol. 177, page 726 (1954).



Thirty-six of the new cars for the Canadian Pacific Railway will have scenic domes.

DISC BRAKES APPLIED TO RAILWAY CARRIAGES

The equipment of 173 stainless-steel streamlined carriages which the Budd Company of Philadelphia are building for the Canadian Pacific Railway includes disc brakes in which the braking effort is applied by asbestos-compound shoes to an air-cooled cast iron disc on the inside hub of each wheel. The braking action is thus transferred from the wheel rim so that wear is reduced and smoother and quieter stopping achieved, owing to the coefficient of friction being constant irrespective of the speed, load or pressure. Further advantages are that a train so fitted can be brought to rest within a shorter distance than when clasp brakes are used, that the life of the asbestos shoes is much longer and that the number of parts is halved, so that maintenance is facilitated. The saving in weight is 2,000 lb. per car. The brakes are operated by compressed air at a pressure of 100 lb. per square inch and are designed to produce a net deceleration of about 3 m.p.h. per second on dry track.

Remarkably long service is said to be obtained from the asbestos shoes of the disc brakes—100,000 miles or more compared with 6,000 miles for clasp-brake shoes. In addition, the disc brakes will not overheat—an important point on the long down grades of the Canadian Pacific.

The bogies of all the cars have a wheelbase of 8 ft. 6 in. and are of the four-wheel single drop equaliser type with bolster and equaliser coil springs. The bolster is of cast steel and consists of a one-piece channel to which a bumper pad and centre plate are secured. The spring planks are of steel and are also cast in one piece. Forged-steel swing hangers and cross bars of the outside type are used, an arrangement which, combined with the spring bolster suspension, reduces rolling and increases smoothness and stability. The vertical and lateral motions of the bolster are damped by shock absorbers of the Houdaille friction snubber type.

A supply of electricity on all the cars is obtained either from a storage battery when they are at rest or from an axle-driven dynamo when they are running. With the exception of the baggage-dormitory car all the cars are also equipped with a motor-alternator from which the fluorescent lighting, radio receivers, public address system, electrostatic air filters and socket outlets for various purposes are supplied.

HEATING AND AIR-CONDITIONING

Heating is effected by low-pressure steam on a system supplied by the Vapor Heating Corporation and designed to operate in temperatures as low as − 40 deg. F. The system, which serves both panels and radiators, is thermostatically controlled and the observation domes are equipped with a light-sensitive thermostat which reduces the cooling in the dome section only when the natural heat of the sun is lowered. In the day cars the heating is also automatically controlled by a " day " and " night " switch. All the cars are equipped with air-conditioning units of the electro-mechanical type, the air circulation varying from 2,400 cub. ft. to 1,200 cub. ft. per minute. The system incorporates a blower unit, which is installed in an overhead plenum chamber and delivers air through anemostats, panels or grilles.

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LIFE IN A.D. 2000

The results of the bicentenary competition of the Royal Society of Arts, for forecasts of practical aspects of life on the earth in the year A.D. 2000, have been announced. The entries submitted numbered 184, but the judges appointed by the Council were unable to make any recommendation for the first prize of £250 or the second prize of £100. The Council, however, have made the following awards: a prize of £50 to Wing Commander T. R. Cave-Browne-Cave, C.B.E., M.I.Mech.E., F.R.Ae.S., of Southampton, for a scheme for rooftop roadways. A prize of £20 to Mr. C. E. H. Watson, B.Sc. (N.Z.), M.I.C.E., A.M.I.Mech.E., A.M.I.Struct.E., of Walton-on-Thames, for a system of underground roadways for London. A prize of £10 to Mr. F. R. East, A.C.I.S., of Horbury, near Wakefield, for a paper on synthetic food. A prize of £10 to the Rev. C. W. Gibbons, B.Sc., of Cambridge, for a paper on education, and a prize of £10 to Mr. M. B. McEvedy, M.A., B.M., B.Ch., D.Obst., of Manchester, for a paper on microbiological products.

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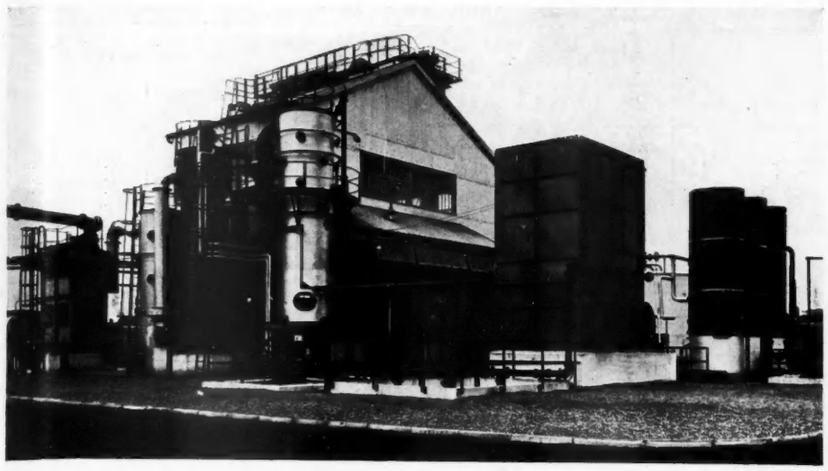
AIR FERRY TO BELFAST

Silver City Airways have applied to the Air Transport Advisory Council for permission to operate a daily all-freight service between Blackbushe and Newtownards Airport, Belfast, with stops at Birmingham and Woodvale, Lancashire. They also request the right to carry cars over the 128 miles between Woodvale and Belfast. The service, if approved, would begin next summer using Bristol 170 aircraft capable of carrying a 5-ton load or three cars.

Silver City Airways also applied to operate up to 12 vehicle- and passenger-ferry services each day between Stranraer and Newtownards.



The Stafford catalytic oil-gas plant produces 1 million cub. ft. of gas a day from residual oil.

GAS FROM RESIDUAL OIL

CATALYTIC OIL-GAS PLANT AT STAFFORD

The catalytic oil-gas plant at the Stafford Works of the West Midlands Gas Board, which was inaugurated by Mr. H. Fraser, M.P. for Stafford and Stone, deputising for the Minister of Fuel and Power, Mr. Geoffrey Lloyd, M.P., on November 19, is the first plant of its type to be erected in this country. The Gas Board were led to consider the question of commercial gasification of residual oil from refineries in 1949, as a result of the increasing shortage of good carbonising coal and its rising price. At the same time it appeared that gas oil would become increasingly expensive because of the demand for the middle fractions of the oil-refining industry for Diesel traction and similar purposes. Residual oil is used extensively on the Continent in place of the traditional gas oil for enriching water gas, but there is a marked difference between the residual oil available in the United Kingdom and that used on the Continent. Continental refineries are mostly without catalytic-cracking facilities, and their residual oil contains a large proportion of paraffinic compounds, which are suitable for thermal cracking in carburetted water-gas plants. In the British Isles most of the refineries are equipped with catalytic-units, and the residual oil lacks paraffinic compounds. In 1949 little was known about the gas-making potential of these residual products, and nothing at all about the necessary technique. The Board therefore appointed a small engineering committee to investigate the problem.

Experiments on the use of residual oil for the enrichment of carburetted water-gas were initiated in 1950 at Saltley Gas Works, Birmingham. A new approach was then made, and in 1951 a small water-gas plant at Solihull Gas Works, near Birmingham, was converted for the catalytic gasification of residual oil on what is known as the regenerative principle. While the Solihull plant was being altered, a visit was paid to Cahors, in France, where an experimental catalytic plant had been built by Gaz à l'Eau et Industriel (GEGI). The results of the work done there were so impressive that it was decided to use at Solihull the ONIA catalyst which was being used at Cahors. Experience gained at Solihull has shown the catalyst to be completely successful.

Following the French visit the Board decided to erect a catalytic oil-gas plant for a production of one million cub. ft. of 450-B.Th.U. gas a day, the plant to be generally of the ONIA-GEGI type developed at Cahors, but to be equipped with a regenerator. An order for the plant was placed with Humphreys and Glasgow Limited, London, S.W.1, originally for erection at Cannock, Staffordshire, but later, in view of changed supply and demand conditions, at Stafford.

CYCLIC OPERATION

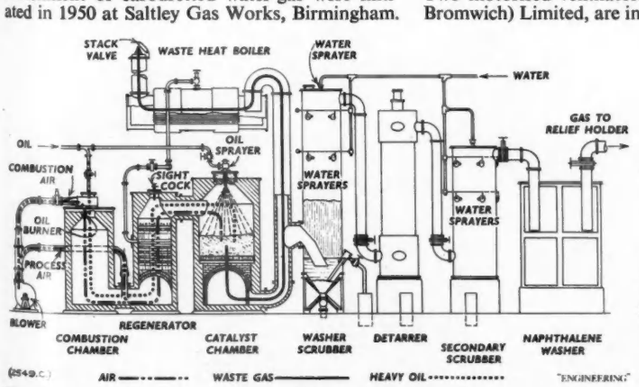
Structurally, the plant is simple. It consists of a combustion chamber in which heavy oil is burnt, a pre-heater or regenerator, and a catalyst chamber in which the gas is made. It is housed in a steel-framed, sheeted building with 4½-in. brickwork panels up to a height corresponding to the eaves level of the adjoining blower room. Two motorised ventilators made by Hills (West Bromwich) Limited, are incorporated in the main roof of the building. The blower room is of cavity wall construction and houses in addition to the two air blowers, the oil pumps and secondary oil heater, boiler feed pumps, electric distribution board, and de-tarrer rectifier. The plant operates on an 8·7-minute cycle, the two phases being a blow and a make period, as shown in the diagrams reproduced below. The cycle is fully automatic, being under the control of a Humphreys and Glasgow automatic operator, which is housed adjacent to the instrument panel, as shown on page 738. The operator is electrically driven through a worm gearbox, twin cranks and connecting rods, ratchets and a camshaft. Gas-cleaning equipment is coupled to the plant, and there are two 20,000-gallon heavy-oil storage tanks with steam heaters at the outlets. Oil is delivered to the plant through further steam heaters by two electric pumps.

The plant is brought to working temperature by burning oil in the combustion chamber, a steel vessel lined with refractory bricks. It can be started from cold in 8 to 12 hours, and after a temporary shut-down gas-making can be recommenced in 1 to 2 hours after lighting the burner. In operation oil is burnt with primary air in the combustion chamber and a mixture of air and combustion products flows from this chamber through the pre-heater, which is also refractory-lined and partly filled with chequer bricks. Secondary air is admitted at a point between the combustion chamber and the regenerator. After leaving the pre-heater the combustion products pass through the catalyst chamber and thence to a waste-heat boiler. The catalyst chamber is refractory-lined and carries the catalyst on a broken refractory base supported by a brick arch. The waste-heat boiler is of the horizontal fire-tube type set to blow off at 100 lb. per square inch. Some fluctuation in steam pressure is inevitable, as a result of the intermittent heating and the process steam for the plant is taken off through a reducing valve and used at 50 lb. per square inch.

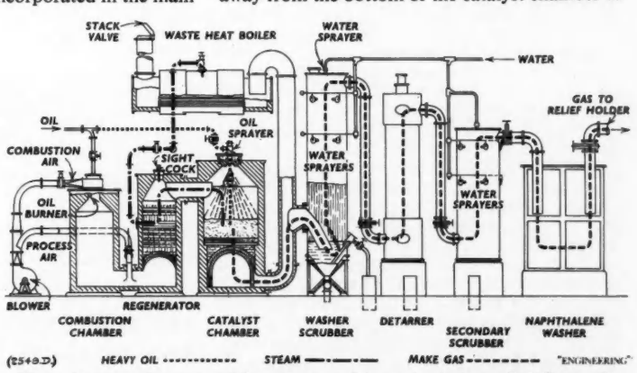
GAS-MAKING

At the end of the blow phase the combustion air and oil are cut off automatically, oil is sprayed into the catalyst chamber on top of the catalyst, and steam is introduced into the chamber via the pre-heater. Such proportions of the oil as will volatilize and gasify by heat are probably gasified during the spray part of the make cycle, and the character of the gases thus evolved is changed by their passage through the hot catalyst. Concurrently with the change in the volatilized oil there is also a reaction between the highly-superheated steam and the carbon, both in suspension in the gas stream and deposited on the catalyst. This liberates hydrogen from the steam and causes a combination of oxygen with carbon to form carbon monoxide. Other and more complex reactions also take place during the make phase. Any carbon left on the catalyst after the make phase is concluded is burnt off during the following blow phase. The secondary air supply ensures that this occurs.

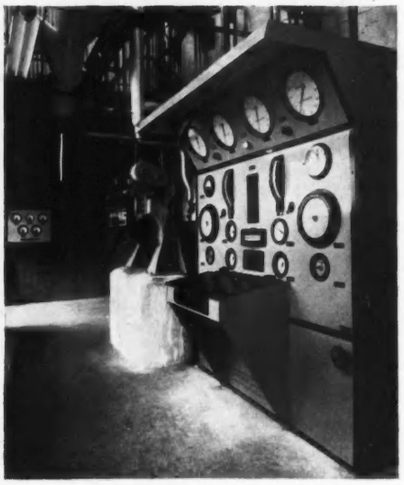
Gas produced during the make phase passes away from the bottom of the catalyst chamber to



The oil-gas plant operates on an 8·7-minute cycle in two phases (" heating " and " gas-making "). The heating-phase flow circuit is shown here.



Flow diagram for gas-making phase. After a temporary shut-down, the plant, which employs a regenerator, can be restarted in 1 to 2 hours.



Operation is automatic, the blow and make cycles being controlled by the automatic operator seen in the centre of the illustration beside the instrument panel.

a washer-scrubber, followed by an electro-static de-tarrer, a secondary scrubber, and a naphthalene washer. It is then passed through a small buffer gasholder, which is necessary because the process is discontinuous, enters the main gas stream from the other parts of the works, and goes to the normal purification plant.

NICKEL-BASE CATALYST

The catalyst used at Stafford was developed by Dr. Marcel Patry, director of research of ONIA at Toulouse. Its detailed composition has not been disclosed, but it has nickel as its essential element. It is well known that nickel will promote reaction between hydrocarbons and steam, but it is readily poisoned by sulphur. Dr. Patry claims that the difficulty of sulphur poisoning has been overcome by the introduction of suitable elements into the catalyst ; these convert, fix and remove the sulphur during the operational cycle. The catalyst was severely tried at Solihull, and proved surprisingly resilient.

OPERATING RESULTS

As the residual oil available in this country is more difficult to gasify and liberates more carbon than the Continental oil, much further operating experience will be necessary before the full efficiency expected at Stafford is reached. The best figures to date are approximately 1·31 therms of gas per gallon of residual oil of 1,000 seconds viscosity Redwood (1), when producing gas of 450 B.Th.U. per cub. ft. The oil for heating is approximately one gallon per 1,000 cub. ft. The whole of the steam for gas-making, oil heating and tar treatment is provided by the waste-heat boiler. The plant is entirely automatic and can be supervised by one attendant, though in the early stages more technical supervision has been necessary. Experience so far has shown that the oil available in this country can be gasified successfully to produce a gas which is entirely interchangeable with town-gas and at a figure which is lower than the normal cost of production of carburetted water-gas. It is considered that in certain circumstances catalytic oil-gas could be produced as cheaply as coal gas, especially when coal transport charges are high. Unless fuel oil can be obtained much more cheaply, however, the process cannot compete as yet against the coke oven or the normal carbonisation technique in large modern works with reasonable freight charges. Typical operating data are given in the appended table.

Following the inauguration of the catalytic gas plant the Mayor of Stafford, Councillor C. Jones, inaugurated a new spiral-guided gas-holder which had been built as a part of the development scheme initiated by the former Stafford Corporation Gas Committee and carried through by the Gas Board. In 1949, there were four gasholders at Stafford, with a total capacity of 1,550,000 cub. ft. which was insufficient for growing demands. An order was therefore placed with R. and J. Dempster, Limited, Manchester, for a four-lift spiral-guided gas-holder of 2 million cub. ft. capacity. The design and construction of the foundations, which were built on alluvium, were undertaken by West's Piling and Construction Company, Limited.

Piling was started in August, 1949, and 431 shell piles each 17¼ in. diameter were driven, the depths varying between 47 ft. 6 in. and 70 ft. A reinforced concrete slab 155 ft. diameter and 10 in. thick was then constructed on the piles. Erection of the gasholder began in February, 1951, and was completed in October, 1953. The holder rises from a steel tank 153 ft. diameter and 32 ft. 4 in. deep, containing 3½ million gallons of water. A Dunfermline man-hole is provided in the top row of tank plates to enable a diver to enter the tank while the holder is in operation. The outer lift of the holder is 150 ft. diameter, the third lift 147 ft. 1 in. diameter, the second lift 144 ft. 2 in. diameter, and the inner lift 141 ft. 3 in. diameter. All four lifts are 31 ft. 8 in. deep. The holder is at some distance from the works steam mains and a Cochran hand-fired boiler is provided for frost protection.

TYPICAL OPERATING RESULTS

	10-minute Cycle With Two-layer Catalyst			8·7-minute Cycle With Two-layer Catalyst			8·7-minute Cycle With Single-layer Catalyst Only		
Average C.V. of run ..	430	447	475	440	457	490	460	480	496
Date	19.5.54	28.5.54	28.5.54	2.6.54	15.6.54	26.7.54	19.8.54	11.8.54	10.8.54
Specimen gas analysis :									
CO_2	10·1	10·5	14·0	12·0	13·5	12·8	12·2	9·0	10·4
C_nH_m	1·7	3·0	5·4	4·2	3·5	3·9	3·6	3·4	3·4
O_2	0·1	0·2	0·2	0·2	0·3	0·2	0·4	0·4	0·4
CO	24·2	22·0	15·7	20·1	16·8	16·7	15·5	17·6	19·4
H_2	46·2	45·6	46·3	45·0	46·3	48·3	41·4	44·6	38·8
CH_4	14·4	15·3	15·2	15·1	15·4	14·4	19·8	16·2	23·0
N_2	3·0	3·4	3·2	3·4	4·3	3·7	7·1	8·8	4·6
Specific gravity	0·57	—	0·61	—	0·62	0·73	0·60	—	0·62
Cyclic heat oil, gallons per 1,000 cubic feet ..	0·78	0·67	1·30	0·72	0·87	1·00	1·13	1·19	1·15
Make oil, gallons per 1,000 cubic feet ..	3·3	3·72	4·49	3·59	3·51	4·66	4·26	4·35	4·54
Total oil, gallons per 1,000 cubic feet ..	4·08	4·39	5·79	4·31	4·38	5·66	5·39	5·54	5·69
Therms per gallon oil make	1·31	1·21	1·06	1·20	1·30	1·05	1·12	1·10	1·09
Therms per gallon total oil	1·06	1·03	0·82	0·99	1·04	0·86	0·90	0·87	0·87
Efficiencies (oil at 18,300 B.Th.U. per cubic foot) :									
Therms in gas Therms in make oil	74·0%	68·4%	60·0%	67·8%	73·5%	59·3%	63·3%	62·1%	61·5%
Therms in gas Therms in total oil	60·0%	56·4%	46·3%	55·9%	58·8%	48·6%	50·9%	49·2%	49·2%

AIR-COOLED DIESEL ENGINES

MODELS RANGING UP TO 100 B.H.P.

A series of five air-cooled Diesel engines has recently been introduced by J. and H. McLaren, Limited, Leeds. They will be known as the Petter-McLaren PD range. The models are built as two-, three-, four-, six- and eight-cylinder engines, the first three being " in-line " and the latter two V types. The largest has a rating of 100 brake horse-power and the series is claimed to have the widest power range of any British-built air-cooled Diesel engines. The four-stroke cycle is used and the bore and stroke are 114·3 mm. and 110 mm. respectively. At 1,800 r.p.m., the b.m.e.p. is 77 lb. per square inch giving an output of approximately 12 brake horse-power per cylinder. The V8 engine is shown in Fig. 1, and a cross section of an in-line version in Fig. 2.

Air cooling has the advantage that a circulating water system is avoided and the engines are rendered rather more adaptable to extreme conditions of climate and site. Also, it is claimed that cylinder wear is reduced as the running temperature is reached more quickly and over-cooling is not possible. The cylinder bank is completely cowled and the cooling air is blown through by an axial-flow fan; in the case of the V-type engines there is a fan for each bank. Baffle plates within the cowling guide the air

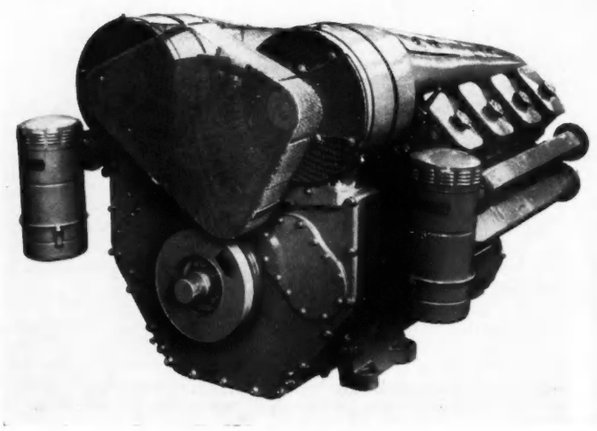


Fig. 1 The largest of the air-cooled range is the V8, rated at 100 b.h.p. at 1,800 r.p.m. Other sizes have two, three, four or six cylinders.

around the cylinder blocks. When tested at tropical temperatures equivalent to a 16 per cent. overload at tropical rating, the temperature differences between cylinders did not exceed 20 deg. F., and the air leaving the cowling was less than 80 deg. F. above the ambient temperature. The lubricating oil-cooler which is fitted in the cowling kept the sump temperature to about 100 deg. F. above the ambient temperature under the same conditions of tropical test.

The crankcase is cast iron and carries the crankshaft in underslung bearings. Side facings on the case allow different mounting brackets to be fitted according to requirements. It is also possible to fit a trunnion support at the front end. The cast-iron cylinders are separate and are secured by long studs which also pass through the cylinder head. The cylinder castings are symmetrical. In all models a Meehanite crankshaft is used, with two pistons on each pin in the V models. The camshaft is forged steel. Forced lubrication is provided by a gear pump which passes the oil through a filter to the camshaft, crankshaft and big-end bearings, and to the timing and rocker gear. The overflow from the latter lubricates the push rods and cams. The cylinder walls and gudgeon pins rely entirely on splash lubrication from the oil in the sump.

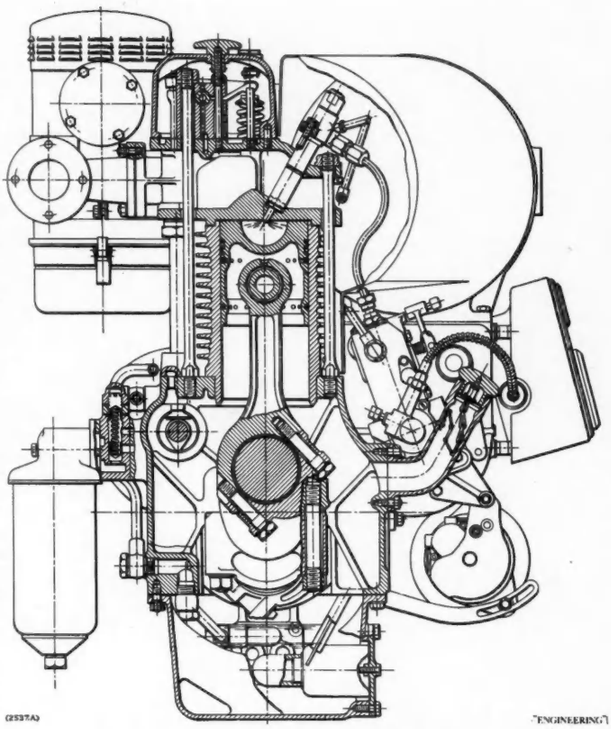


Fig. 2 Cross-section of one of the in-line models.

Aluminium pistons are used having hemispherical combustion chambers in the crown. The multi-hole injector is placed centrally. Fuel is supplied by a block-type pump which in the V models is mounted between the banks. The engine speed is controlled by a centrifugal governor built in the fuel-pump driving wheel and confirming to B.S. 649-1949. Hand adjustment gives a speed variation of ± 10 per cent. and by changing the speeder spring any constant speed between 1,000 and 1,800 r.p.m. can be obtained. If required, variable speed governing can be fitted. Air cleaners are fitted to the manifold intake as may be seen in Fig. 1.

The performance curves shown in Fig. 3 are for a four-cylinder engine running under normal atmospheric conditions. Standard grade fuel was used. In order to give a good performance directional ports and masked inlet valves are used. The engines have a compression ratio of 16 to 1, but all can be hand started in most applications since decompressor gear is fitted. Where the light flywheel renders this difficult, however, electric starting equipment can be fitted. The majority of parts are interchangeable between the in-line and V models, thereby making for easier servicing.

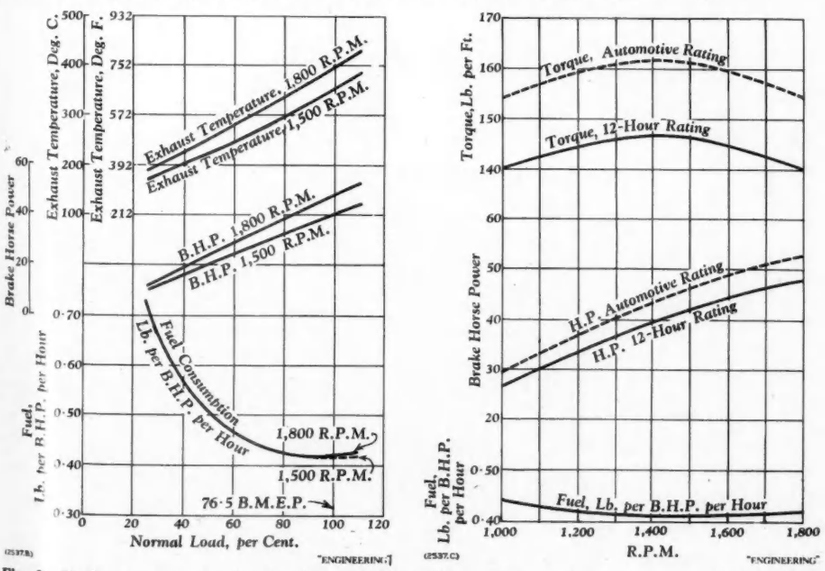


Fig. 3 Performance curves for the four-cylinder in-line engine running under normal atmospheric conditions.

LAUNCHES AND TRIAL TRIPS

M.S. "TALARA."—Single-screw oil tanker, built and engined by Burmeister and Wain, Ltd., Copenhagen, Denmark, for the Direccion General de Administracion de Marina, Lima, Peru. Main dimensions: 335 ft. 10 in. by 50 ft. 10 in. by 22 ft. 6 in., deadweight capacity, 4,800 tons on a draught of 19 ft. 1½ in.; oil-tank capacity, 5,500 cub. metres. B. and W. six-cylinder single-acting two-stroke oil engine, developing about 2,200 b.h.p. at 115 r.p.m. Speed, 12½ knots. Delivered, October 20.

M.S. "PORT SYDNEY."—Twin-screw cargo vessel, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for the Port Line, Ltd., London, E.C.3. Main dimensions: 498 ft. between perpendiculars by 70 ft. by 42 ft. to upper deck; deadweight capacity, 11,000 tons on a draught of 28 ft. 10 in.; refrigerated cargo space, 330,000 cub. ft.; unrefrigerated cargo space, 332,500 cub. ft.; gross tonnage, about 9,800. Two Wallsend-Doxford six-cylinder single-acting two-stroke oil engines, together developing 13,200 b.h.p. at 112 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 17 knots. Launch, October 29.

M.S. "SUSANNE SKOU."—Single-screw cargo vessel, with accommodation for ten passengers, built and engined by Burmeister and Wain, Ltd., Copenhagen, for Ove Skou Ltd., Copenhagen, Denmark. Main dimensions: 400 ft. between perpendiculars by 56 ft. 6 in. by 35 ft. 6 in. to upper deck; deadweight capacity, 7,050 tons on a draught of 24 ft. 8 in.; cargo capacity, 434,000 cub. ft. (bales). Six-cylinder single-acting two-stroke Diesel engine, developing 7,500 b.h.p. at 115 r.p.m. Speed, fully loaded, 17 knots. Delivered, November 4.

M.S. "ZEALAND."—Single-screw cargo vessel with accommodation for twelve passengers, built by Henry Robb, Ltd., Leith, for the Leith to Copenhagen service of the Currie Line, Ltd., Leith. Main dimensions: 270 ft. between perpendiculars by 45 ft. by 25 ft. 6 in. to upper deck; deadweight capacity, about 1,850 tons on a mean draught 17 ft. 3 in. Two seven-cylinder two-stroke uni-directional Diesel engines, developing a total of 2,260 b.h.p. at 300 r.p.m., arranged to drive through two Barclay Curle "Vulcan" hydraulic couplings and a reverse-reduction gearbox to a single propeller shaft running at 125 r.p.m. Service speed, 13 knots. Launch, November 10.

S.S. "FORTHFIELD."—Single-screw oil tanker, built and engined by Hawthorn Leslie (Shipbuilders), Ltd., Hebburn-on-Tyne, County Durham, for Hunting and Son, Ltd., Newcastle-upon-Tyne. Main dimensions: 557 ft. overall by 69 ft. 3 in. by 39 ft. to upper deck; deadweight capacity, about 18,000 tons. Double-reduction geared steam turbines developing a maximum of 8,250 s.h.p. and two Foster Wheeler water-tube boilers. Launch, November 10.

S.S. "THESEUS."—Single-screw cargo vessel, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Australian trade of Alfred Holt & Co., Liverpool. Main dimensions: 489 ft. overall by 64 ft. by 35 ft. 3 in. to upper deck; deadweight capacity, 9,500 tons. Three-cylinder cross-compound steam turbine, to develop a maximum of 8,000 s.h.p. at 112 r.p.m., constructed by Metropolitan-Vickers Electrical Co., Ltd., Manchester. Steam supplied by two Foster Wheeler oil-fired single-furnace boilers, constructed by D. Rowan & Co., Ltd., Glasgow. Service speed, 16 knots. Launch, November 10.

S.S. "SIR WILLIAM WALLACE."—Single-screw collier, built by Austin and Pickersgill, Ltd., Sunderland, for the British Electricity Authority, London, W.1. (Managers: Stephenson Clarke, Ltd., London, E.C.3.) Main dimensions: 340 ft. overall by 43 ft. 6 in. by 20 ft. 3 in. to upper deck; deadweight capacity, 3,680 tons on a summer draught of about 18 ft. Direct-acting triple-expansion steam engine of reheat design, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam supplied by two oil-burning boilers. Service speed, 11 knots. Trial trip, November 11.

M.S. "STORAAS."—Single-screw oil tanker, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for Iver Bugge, Larvik, Norway. Stated to be the largest vessel so far constructed on the East coast of Scotland. Main dimensions: 530 ft. between perpendiculars by 72 ft. by 39 ft. to main deck; deadweight capacity, 18,075 tons on a draught of 29 ft. 10½ in.; gross tonnage, 12,075. Harland and Wolff/Burmeister and Wain seven-cylinder single-acting two-stroke Diesel engine, developing 8,000 b.h.p. at 112 r.p.m., constructed by Harland and Wolff, Ltd., Belfast, and installed by the shipbuilders. Speed 15 knots. Trial trip, November 12.

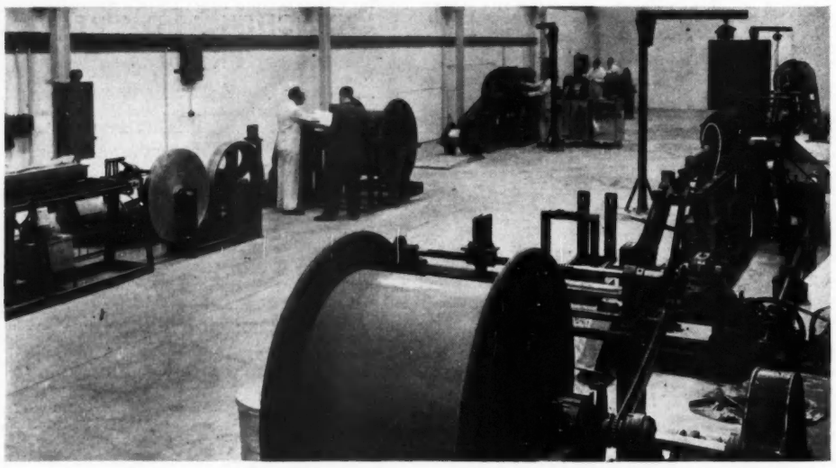


Fig. 1 In the stranding-machine shop the central conductor is prepared by wrapping three thin copper tapes round a solid copper wire.

PRODUCTION OF THE TRANSATLANTIC TELEPHONE CABLE

NEWLY-EQUIPPED FACTORY AT ERITH

The manufacture of nearly 90 per cent. of the 1,950 nautical miles of submarine telephone cable which will be the first of the two to be laid across the Atlantic, between Oban in Scotland and Clarenville in Newfoundland, has begun; and it is hoped that after the necessary repeaters have been inserted laying will be started during the summer of 1955. The cable is being made by Submarine Cables Limited, Greenwich, London, S.E.10, in a factory which has been established at Erith and which was formally opened by the Postmaster-General (the Rt. Hon. Earl de la Warr) on Friday, November 26.

This factory has been used because the main works of the Company at Greenwich were not large enough to handle a contract of this size without disturbing the existing programme of manufacture. Erith was chosen as the site since it is ideally situated on the banks of the Thames. It is also convenient for administration and the existing buildings were large enough for conversion to a modern submarine cable factory. The shop area is about 150,000 sq. ft. and the plant installed will be capable of producing up to 4,000 miles of cable per annum.

The conversion necessitated a considerable amount of piling to provide foundations for the large machines and the cable storage tanks, while a dredged berth and dolphins have had to be provided for H.M.T.S. Monarch on which the cable is to be loaded.

CABLE DESIGN

A description of the cable has already been given in ENGINEERING (November 12, page 638). It consists of a central conductor made up of a solid copper wire 0·1318 in. in diameter, which is surrounded by a layer of copper spiralling and abutting tapes. These tapes are 0·0145 in. wide and are formed to fit closely round the solid wire with a minimum of voids. The core thus formed is insulated by a layer of Polythene 0·62 in. in diameter over which the return conductor is laid. This conductor is also a flexible structure and consists of a single layer of six abutting spiral tapes, which are formed into a tube. It is covered with an overlapped helical tape for protection against teredo over which Teleconax tape and a jute serving are wound. Finally, galvanised mild steel or high tensile steel armouring is applied depending on the depth at which the cable is to be laid. The overall diameter varies from 2·68 in. for the shore ends to 1·21 in. for the lengths laid at the greatest depths.

The manufacturing processes do not differ greatly from those usual in this class of work. The machinery used is, however, of the most modern type; and some of it incorporates details which experience with some of the latest cables has shown to be desirable. Extreme accuracy in manufacture is an essential feature, since the attenuation of a cable of this length varies from 900 to 3,200 decibels at the lower and higher ends of the transmitted frequency band respectively. The transmission level at any frequency must be maintained to avoid overloading the repeaters at high levels and to eliminate interference at low levels. Consequently, the variation of the attenuation with the frequency must be accurately equalised at each repeater. Moreover, the temperature and pressure conditions at the sea bed must be predicted, as the cable characteristics depend to a considerable extent on these variables. Finally, as the deep sea repeaters will not contain matching units their gain will be affected by irregularities in the cable impedance due to reflections. These conditions are being met at Erith by careful control of the quality and dimensional tolerances both of the raw materials and the product.

ACCURACY TESTS DURING PRODUCTION

The first stage of production is the mixing of small cubes of polythene, supplied by I.C.I. Ltd., with butyl rubber and an anti-oxidant to improve its mechanical properties. The inner conductor is prepared on the machines illustrated in Fig. 1 by wrapping three copper tapes round the central wire. This stranded conductor is then passed through the extruders where the polythene mixture is applied and the insulated core is next cooled in a long trough before being wound on to drums. At this stage frequent measurements are taken of the diameter and length of the product after which electrical tests, lasting 24 hours, are carried out with the core immersed in water at a controlled temperature.

On the completion of these tests, lengths of core are jointed in air-conditioned galleries and are then passed to the machines illustrated in Fig. 2, where the six copper tapes and binding tape forming the outer conductor, as well as a binding tape and jute serving, are simultaneously applied. On leaving these machines the served core is fed into tanks where it is temporarily stored and where further tests are made. The armouring machines, one of which is shown in course of erection in Fig. 3, are used to apply the steel armour wires, two layers of jute outer serving and three layers of compound in one operation. Before application the jute used on the inner serving is cutched, while that on the outer serving is impregnated with tar. Finally, the armouring is coated with compound and wrapped with impregnated cotton tape as a protection against corrosion by sea water. The overall diameter of the cable varies from 2·68 in. for the intermediate and shore end cables to 1·21 in. for the deep sea portions. The deep sea cable weighs 3 tons per nautical mile.

STORING COMPLETED CABLE

As manufacture is completed the cable is being stored in one of 12 tanks, each of which is capable of holding about 185 nautical miles of the deep sea type, the temperature of the water being kept uniform so that final testing can be carried out. As has already been announced, flexible one-way repeaters, designed by the Bell Telephone Laboratories, will be inserted in the deep sea portion of the cables at intervals of about 37 nautical miles. These repeaters are being manufactured by the Western Electric Company of America and will be shipped to this country for splicing into the cable at Erith. The two-way repeaters which will be used on the shallow water sections will be of the British Post Office rigid type. They are being manufactured by Standard Telephones and Cables, Limited, Aldwych, London, W.C.2, and will be assembled in housings supplied by Submarine Cables, Limited. That portion of the cable for which

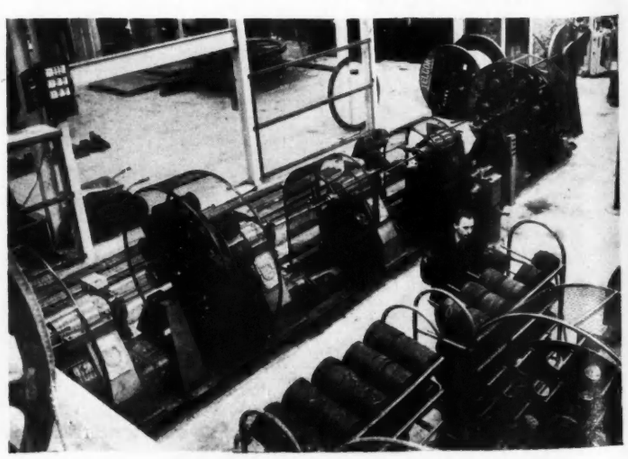


Fig. 2 This machine wraps the copper return tapes round the insulated conductor and applies the jute bedding for the armouring wires.

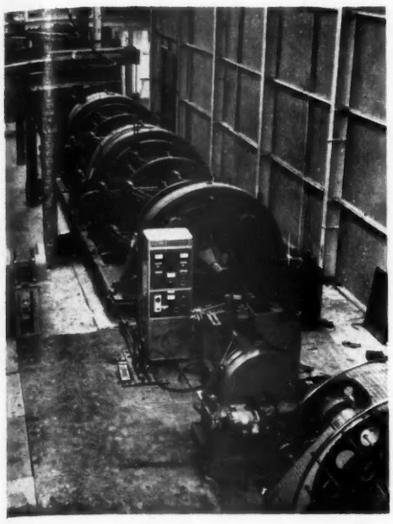


Fig. 3 These machines, shown in course of erection, apply the steel armour, two layers of jute, and three layers of compound.

Submarine Cables, Limited, is not responsible is to be made by Simplex Wire and Cable Company, Boston, Massachusetts.

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SUBMERSIBLE ELECTRICALLY-DRIVEN PUMPS

The accompanying illustration shows a 1,000-h.p. double-cage four-pole submersible motor which has recently been completed at the works of Hayward-Tyler and Company, Limited, Luton, and is designed to operate at 3·3 kV and a speed of 1,475 r.p.m. Although the firm has for a long time made submersible pumps driven by three-phase motors with outputs up to 450 h.p. at 550 volts, these give rise to supply difficulties if direct-on starting is used, while to employ auto-transformers with on-load tap changing for this purpose adds to the cost. To overcome these drawbacks, a higher voltage is now being utilised, a course which is rendered possible by the use of polyvinyl chloride as an insulating material. It is also possible in this way to reduce the ratio of starting current to load current from about 6·0 to 3·2 and to keep the starting torque down to about 35 per cent. of the full load torque. Further there is a saving in the copper required in the feeder cables.

The unit illustrated has been arranged as a dynamometer motor for testing the firm's centrifugal cargo pumps and for that purpose is mounted in a swinging frame. Both the plain and thrust bearings are water-lubricated and cooled. The diameter of the stator casing is 30·5 in., the overall length 9 ft. 4 in. and the weight about 7½ tons. This diameter is rather larger than that of the corresponding 550-volt units, owing to the necessary increase in the number of stator turns and the greater thickness of the insulation.

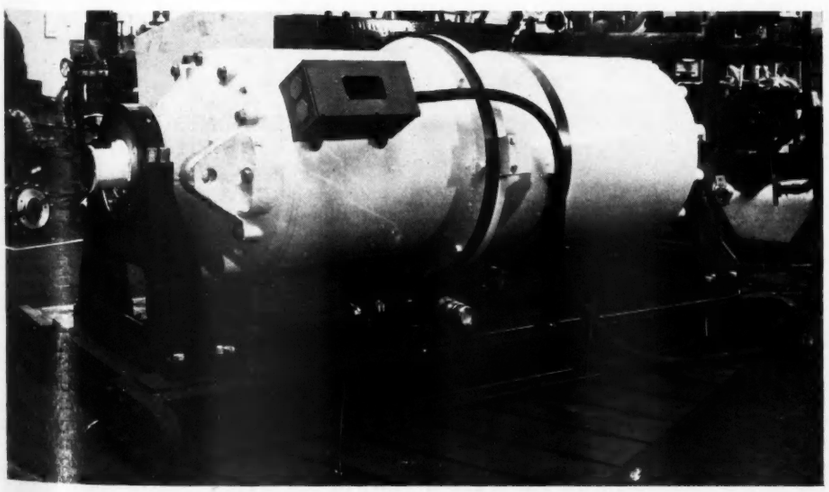
BOILER CIRCULATING PUMP

Another product of the firm is an " Electromersible " feed-water circulating pump, intended for use in conjunction with La Mont boilers working at pressures up to 4,150 lb. per square inch. The pump and its motor form a vertical unit. The casing of the former is bolted direct to the boiler circulating pipes, while the motor is spigoted into the pump body. The impeller is carried at the lower end of the shaft, the downward hydraulic thrust and the weight of the rotating assembly being borne by a tilting-pad thrust bearing, which is designed for water lubrication. The journal bearings are also of the tilting-pad type.

The cast Monel-metal impellers and diffusers are designed to ensure the lowest possible fluid and rotational velocities and thus provide the maximum freedom from cavitation without the use of abnormally high submergence heads. They are balanced statically and dynamically on the motor stator. The stator of the motor is insulated with polyvinyl chloride, the ends of the windings being bonded to a pre-moulded cable seal. As the squirrel cage is of metal with a high electrochemical potential it is totally-enclosed in a steel sheath. The journal sleeves are of asbestos-filled plastic, which is moulded on to a metal sleeve.

MOTOR COOLING SYSTEM

During normal operation the pump operates at the full boiler temperature, while that of the motor must not exceed 140 deg. F. To maintain this difference the casing between the pump and motor is externally pinned, and baffle plates are installed above the impeller to prevent the mixture of the hot and cold water. The motor shaft is also hollow for part of its length, the space being filled with water. In addition, cooling water is forced through the thrust and journal bearings, rotor gap and stator windings.



1,000-h.p. submersible motor, which operates at 3·3 kV, mounted with a pump on a swinging frame for use as a dynamometer.

PRESTRESSED-CONCRETE RAILWAY BRIDGE

Concrete Placed in Situ

A new single-line prestressed-concrete bridge has recently been completed by London Midland Region (British Railways) to carry the re-aligned down main line over the River Leen, near Radford, for the widening of the Nottingham-Mansfield line. The up and down main lines at this point were previously carried on a single bridge but under the widening scheme one of these lines was to become an up goods loop and the other the up main, the down main being re-sited over the new bridge.

The bridge is of 60-ft. skew span of the through type with main girders at 12-ft. centres and a floor 10 in. thick spanning between them at the bottom-flange level. The main girders are of I-section, 6 ft. deep overall with 27-in. wide flanges and a 9-in. thick web. Prestressing of each of these girders has been accomplished using three Magnel-Blaton cables, two of which, located in the bottom flange, are straight and composed of 40 wires each of 0·276 in. diameter, while the third cable is curved and comprises 32 wires of the same diameter. The floor is thickened at each end to form a skew-end beam spanning between the main girders at the bearings, and the deck has been prestressed by Freyssinet cables, each composed of 12 wires of 0·20 in. diameter.

The bridge was concreted *in situ*, using ready-mixed concrete having a specified 28-day strength of 7,000 lb. per square inch and with the addition of a 1 per cent. plasticiser to assist in obtaining a compact concrete, particularly around the cables at each end of the bridge, where, owing to the skew, the cable arrangement was rather complicated. Internal vibrators were used throughout the work. Concreting proceeded in three stages: (1) half the length of the floor and bottom flanges of main girders; (2) remaining half of floor; and (3) webs and top flanges of main girders. Both steel and timber shuttering was used, supported on a falsework of steel beams erected on the new abutments at each end and on temporary piles driven into the river bed at mid-span.

The two new abutments are of mass concrete faced with brickwork, and were constructed inside cofferdams of steel-sheet piling. Rocker bearings of Meehanite cast iron are provided at each main-girder bearing, and these were set in position before the falsework for the support of the superstructure concrete was erected.

The site work was carried out by direct labour to the design of the Regional Headquarters Bridge Office under the direction of Mr. J. Taylor Thompson, M.C., M.I.C.E., the regional civil engineer.

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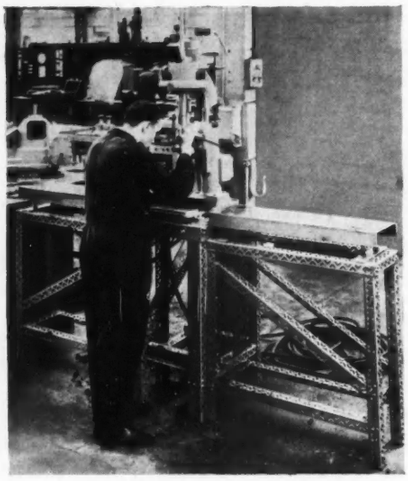
P.L.A. IMPROVEMENTS

Inter-dock Connection to be Widened

The Port of London Authority has decided to proceed with a scheme for widening the cutting between the Greenland and Canada Docks of the Surrey Commercial Docks at an estimated cost of £365,000. This will permit some of the larger vessels which are now restricted to using the Greenland Dock to berth in the Canada Dock. The existing width of the cutting is 60 ft. and this is to be widened to 80 ft. (that is, to the same as that of the entrance lock to the Greenland Dock) by setting back the wall on the north side and at the same time turning the wall at its eastern end to facilitate the passage of ships. Vessels 450 ft. long and with a draught of 25 ft. 6 in. will then be able to pass through the cutting, as compared to 420 ft. and 23 ft. 6 in. respectively, which is now permitted.

A new single-leaf rolling lift bridge will also replace the existing swing bridge over the Greenland/Canada cutting; this will benefit road traffic in the area. It is expected that the work will take rather more than two years to complete.



Framed supports for machines and for structures are readily constructed by unskilled labour, the novel pattern of the slots ensuring that bolted connections can always be made.

SLOTTED ANGLE BARS

Easy Construction of Supporting Frames

The popularity for the slotted angle bar is mainly due to the speed and economy effected during fabrication and its versatility in meeting the requirements of many frameworks of differing dimensions and shape. A new bar is to be added to those already available, this one to be marketed by Chevron Structural Units, Limited, 7 Victoria-street, London, S.W.1. The basic member is an angle with legs of either 2 in. by 2 in. or 3 in. by 2 in. cold rolled from 14-s.w.g. thick steel and punched with a characteristic "chevron"-style slot. The principal claim made for this form is that, due to the overlapping alignment of the slots, it is not possible to place two bars together in such a way that a bolted connection cannot be made; expressed the other way it means that at least one standard bolt can always be used to connect two adjacent Chevron bars whatever their alignment. It is possible with a well-located right-angle joint to use as many as five bolts to ensure rigidity. Applications of the bar are almost unlimited—frames for shelves, supports for light buildings, conveyor belts and, as illustrated, for machines.

The task of assembling, holding two or more bars and bolting them together, is facilitated by the use of the special bolt which has a small projection under the head that prevents it from turning when tightening. A suitable box spanner with a folding handle enables the nuts to be turned with minimum effort.

Ancillary pieces designed for use with the slotted bar includes shelves of various sizes in either 20 s.w.g. or 18 s.w.g. steel; rollers for conveyors, ball-bearing mounted and with ⅜-in. shafts which just register in the apex of the chevron slot; together with castors and hinges. The bar and all the ancillaries are finished in medium-grey stove enamel.

The effective moment of inertia of the 2 in. by 2 in. angle is 0·101 in.^{4} and the section modulus 0·066 in.^{3}; the safe distributed load on a span of 5 ft. for a beam comprising a pair of parallel bars is 290 lb. The same loading for the larger 3 in. by 2 in. angle is 330 lb.

The angle bar is easily cut to size using an ordinary hacksaw; for rapid cutting a cropper is a useful alternative tool. Supplies are generally available in lengths of 8 ft., 9 ft. and 10 ft. and in bundles of 100 ft., each bundle being accompanied by a package of 72 bolts, nuts and washers.

THE CONTROL OF ELECTROPLATING

Combined Instrument Enables Conditions to be Repeated

A new instrument, now being produced by Measuring Instruments (Pullin), Limited, Winchester-street, Acton, London, W.3, has been designed to enable the operating conditions in electroplating vats to be kept constant, and to be repeated from one batch of work to another, as easily and quickly as possible. The instrument is shown in the illustration below and will be seen to consist essentially of an ammeter and a voltmeter combined in a single casing. The independent volt and ampere scales are located near the periphery of the dial and in the centre of the latter is drawn a special chart over which both indicating needles move.

The chart is formed by eight arcs which diverge from the point at which the needles cross when indicating zero on both the scales. The spaces between the arcs, which each form part of a crescent, are lettered at the open ends and are divided into a number of quadrilateral figures by a series of concentric arcs centred on the zero point of intersection of the needles. Each quadrilateral thus formed is numbered so that it can be readily identified by its number and the letter at the end of the crescent-shaped space in which it is included. The design of the chart is such that with any particular constant resistance in the external circuit, the needles always cross over some part of the same lettered space.

The method of employing the instrument in a series of production runs is for an experienced operator to set up the plating vat for the first batch of work, adjusting the current and fixing the time necessary to give the required thickness of plating. He then notes the number and letter corresponding to the quadrilateral over which the needles cross; say, for example, D6. For subsequent batches, the vat is loaded until the needles cross over the same lettered space, D, which indicates that the vat has the same resistance as before; assuming that the strength of the electrolyte has not altered, this means that the same amount of work has been loaded into the vat. The current regulator is then adjusted until the two needles cross over the same quadrilateral as before, namely D 6, when the working conditions for the first batch will have been restored and if the plating is continued for the same time the same thickness of metal will be deposited.

In single-batch work, we understand, the instrument has proved useful as a guide to the best loading and current strength to employ and for the detection of such faults as incorrect strength of electrolyte, damaged anodes, bad connections, etc.

The point of intersection of the two needles of this combined ammeter and voltmeter is used as a reference for resetting the original working conditions.

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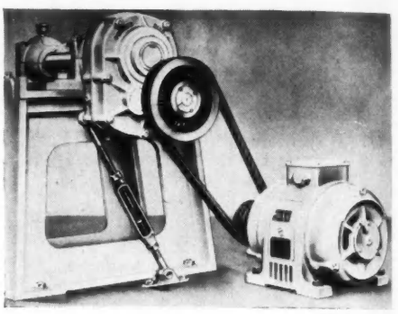
SHAFT-MOUNTED SPEED REDUCER

Simplicity of mounting is the great advantage of the "Torque-Arm" speed reducer developed by J. H. Fenner and Company, Limited, Marfleet, Hull. The speed reducer is made in four standard sizes, has a fixed reduction of 15 : 1, and power ratings of up to 12 h.p.

The reduction unit is mounted directly on the driven shaft, as shown in the accompanying illustration. It is secured by locking the driven shaft into the bore of the reduction unit by means of a collar at either end and anchoring the torque-arm to the nearest fixed object. Bushes are available to adapt the shaft diameter to the bore diameter where the former is less than the latter. Shaft mounting dispenses with bed plates and couplings and eliminates "lining-up" difficulties.



Tensioning the driving belt of the speed-reducer can be done easily with the turnbuckle. The torque arm can be fixed to the floor as shown or to any other suitable point.

The reduction unit is driven through taper-lock V-belt drives, and final fixed speed variation is obtained by using different diameter taper-lock pulleys. Output speed can be varied between 19 r.p.m. and 134 r.p.m., using a 1,440-r.p.m. motor, and between 9 r.p.m. and 134 r.p.m. using a 960-r.p.m. motor. The V-belts assist in absorbing shock loads, and belt-tensioning can be done easily by the turnbuckle on the torque-arm.

The maximum horse-power rating is 12·2 at 134 r.p.m. using the largest standard size. The range of application includes conveyors and elevators, agitators and mixers, screens and graders, and similar slow-speed machinery.

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HIGHEST TRANSMISSION LINE IN BRITAIN

The 132-kV transmission line of the North of Scotland Hydro-Electric Board over the Corrieyairack Pass between Fort Augustus and Speyside, near Newtonmore, Inverness-shire, which was switched on on Tuesday, November 23, is the highest line in Great Britain, the tower at the summit being 2,600 ft. above sea level.

This addition to the Board's Highland system consists of 25 miles of double-circuit line; the towers on which it is carried have special heavy foundations owing to the exposed situation. It was erected by J. L. Eve Construction Company, Limited, and the consulting engineers were Merz and McLellan. It will enable a supply to be given from the Glen Garry, Glen Moriston and Glen Affric power stations to Aberdeen and the north-eastern counties via the Spey Valley and the Lecht Pass, and to the Southern Highlands, Angus and Central Scotland via Tummel Bridge.

Labour Notes

TRADE UNIONS DECLINE IN MEMBERSHIP

A rise in the number of members of trade unions which took place during 1952 was not maintained last year. In 1952, the number of workpeople belonging to trade unions in the United Kingdom rose by 43,000, from 9,481,000 to 9,524,000, and thereby established a record level for trade-union membership in this country. In 1953, however, the aggregate membership of the unions declined by about 63,000, making the total at the end of last December 9,461,000. This represented a reduction in numbers of about 0·7 per cent.

Of the total number of trade unionists at the end of last year, 7,701,000 were men and boys, a decrease of 48,000, or 0·6 per cent., as compared with the previous year, and 1,760,000 were women and girls, a decrease of 15,000 or 0·8 per cent. Last year's total included 45,000 members belonging to union branches in the Irish Republic and about 100,000 belonging to other branches outside the United Kingdom.

It is pointed out in an article on the subject in the *Ministry of Labour Gazette* for November that the figures given above represent the totals of the individual unions and that persons who belonged to more than one union are accordingly counted more than once in the totals. It is believed that the number of dual trade-union memberships is relatively insignificant.

In 1892, the earliest year for which statistics are available, the total membership of the trade unions was a little over 1,500,000, but, 18 years later, at the end of 1910, the figure had increased to 2,500,000.

SIZE OF THE UNIONS

At the end of 1953, there were altogether 687 unions in the United Kingdom, compared with 692 in 1952 and 710 in 1951. Fifteen years ago, at the end of 1939, there were no fewer than 1,019 unions.

During the twelve months ended December, 1945, there was a decline of 182 in the number of active unions, due mainly to the amalgamation of the majority of the coal-mining unions into the National Union of Mineworkers and to constitutional changes in a group of associated organisations in the Civil Service, as a result of which they ceased to function independently of one another.

Although the tendency towards amalgamation has resulted in a progressive decline in the number of separate unions, there still remained at the end of last year 387 unions with fewer than one thousand members and, of these, 317 unions had fewer than five hundred members.

These 387 small unions together accounted for only about 1 per cent. of the total trade-union membership, while, at the other end of the scale, about two-thirds of all trade-union members belonged to the 17 largest unions, and about 92 per cent. to the 90 unions having memberships of 10,000 or more.

AN APPEAL TO PARLIAMENT

Among other measures suggested by members of the Post Office Engineering Union as ways of expressing the dissatisfaction they feel at the lack of progress which is taking place in connection with the union's claim for higher wages was the organising of an appeal to Members of Parliament.

The union's executive council recently decided to adopt that course of action and, on Monday last, every Member of Parliament was due to receive a memorandum on the subject. It gave the history of pay negotiations between the union and the Post Office during recent years and declared that there was widespread discontent among the 66,000 technical employees whom the union represents, just as a programme of telephone expansion is about to begin.

It is the union's contention that the Post Office, by refusing to make offers that could form a basis for negotiation, has failed in its duty as a negotiating party and has repeatedly compelled the union to resort to arbitration.

All wage claims negotiated with the Post Office since 1948, have had to be settled by arbitration and in every instance, the union points out, the Civil Service Arbitration Tribunal has awarded more than the Department was prepared to offer. The attitude of the Post Office, the union complains, has had the effect of turning the Tribunal into a regular means of fixing wage rates, and has created an unhealthy atmosphere in which neither side feels responsible for the wage structure.

INDEPENDENT CHAIRMAN PROPOSED

In a covering letter, Mr. Charles Smith, the union's general secretary, states that the maximum basic rate for fully skilled telephone craftsmen is £7 15*s*. 6*d*. a week on reaching 27 years of age. This rate is increased to £8 10*s*. 6*d*. a week in the case of men promoted to be in charge of groups, and both rates are about 5*s*. higher for men employed in the London area.

Many men, Mr. Smith points out, never get beyond the rate of £8 10*s*. 6*d*. owing to the shortage of vacancies on the external side of Post Office engineering work. Technical officers, who must possess considerable theoretical knowledge as well as practical skill, can reach a maximum of £9 16*s*. (£10 4*s*. in London), but not until they reach 33 years of age.

Another complaint against the Department is in respect of the long delays which are stated to take place in replying to wage claims.

Mr. Smith asks for the support of Members of Parliament for a proposal that the Postmaster-General should agree that a person of standing and experience in industrial negotiations outside the Civil Service, and acceptable to both sides, should be invited to act as chairman at a series of meetings between representatives of the Post Office and the union, in the hope that he may assist in leading the two bodies to an agreement. This proposal, it is emphasised, is made without prejudice to the union's right to have final recourse to arbitration.

At the present time, the union has two wage claims outstanding. One of these was presented in January last.

COMPLAINTS AGAINST LEFT-WING ELEMENTS

Writing in the December issue of the *Transport and General Workers' Record*, the official journal of the Transport and General Workers' Union, Mr. Arthur Deakin, the union's general secretary, complains that a left-wing campaign is being carried on among his members and that it is designed to reach its climax at the union's biennial delegate conference in July, 1955.

Mr. Deakin considers that the union would not have been the target for such sustained criticism and abuse, and he would not have been regarded so constantly as a person to be vilified, had they not stood so firmly by policies determined by the rank and file at previous biennial delegate conferences.

It is said that, when strikes take place and considerable numbers of people become involved, thousands of men cannot be wrong. The good sense of the British workman should not be minimised in any way, Mr. Deakin points out, but it would seem that, during the past few years, people have been moved more by emotion than by reason. This process has continued to an extent quite foreign to the British way of life.

In addition, " strong-arm " methods have been used and people have been moved to take strike action against their better judgment. Quite often, the cause of their action has been a fear complex that they would be classified as " scabs."

DEPARTMENTAL INQUIRY INTO RETIREMENT

The results of an inquiry by the Ministry of Pensions and National Insurance into the reasons why people retire or remain at work after reaching the minimum age for national-insurance retirement pensions (65 for men and 60 for women) are given in a report published last week. This was entitled *National Insurance Retirement Pensions* (H.M.S.O., price 5*s*. net).

The inquiry was made under the guidance of the National Advisory Committee on the Employment of Older Men and Women, and the results have been made available to the committee under the chairmanship of Sir Thomas Phillips which is reviewing the economic and financial problems involved in providing for old age.

Some 29,000 insured men and women were covered by the investigation. They were all persons, who, during the four weeks ended October 11, 1953, were either taking their retirement pensions at the minimum age or later, or were just reaching the age for retirement but staying on at work.

The report records the reasons given by these people for deciding whether to take their pensions or to remain in employment, and the information they gave in respect to such matters as working conditions, pension schemes and family circumstances. It also compares the results with information obtained from other sources, such as recorded incapacity for work due to industrial injury, sickness or disease.

REASONS FOR RETIREMENT

A noteworthy conclusion from the report is that four men, out of every ten reaching the minimum pensionable age, took their retirement pensions. The two main reasons given for this course were action by the men's employers and ill health. The chronic sick accounted for 25 per cent. of those retiring. The remainder of those retiring, about 18 per cent. of the whole, gave a variety of reasons for taking their pensions, such as a wish for more leisure.

Of those who claimed ill health or strain as a reason for retirement, three out of ten had practically no record of incapacity in the years prior to the inquiry, and, in the eight months immediately prior to the inquiry, the proportion was nearly six out of ten. About two men in seven asked the advice of their doctors before retiring.

Six men out of every ten reaching the age of 65 stayed in employment. The principal reasons given were financial need (45 per cent.), felt fit enough (25 per cent.), and preferred to work (20 per cent.). Half of the men declared that the prospect of extra leisure deterred them from giving up work.

Only women insured on their own account are covered by the report, owing to the special arrangements for married women provided by the national insurance scheme.

Of the women taking their retirement pensions at the minimum age of 60, some 15 per cent. claimed to be in the category of the chronic sick. A further 30 per cent, said they had retired owing to ill health or strain. Discharge or retirement by their employers was given as the reason by only 7 per cent.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Heat Pump for Domestic Purposes," by J. A. Sumner. West London Branch. Magnet House, Kingsway, W.C.2. Tues., Dec. 7, 6.30 p.m.
BIRMINGHAM
Film Evening. Birmingham Branch. Chamber of Commerce, 95 New-street, Birmingham. Wed., Dec. 8, 7 p.m.
BRADFORD
"Further Applications of Electronic Control," by G. Craven. Bradford Branch. Midland Hotel, Bradford. Wed., Dec. 8, 7.30 p.m.
CARDIFF
"Theatrical Lighting," by G. W. Timms. South Wales Branch. Angel Hotel, Westgate-street, Cardiff. Tues., Dec. 7, 7.30 p.m.
ILFORD
"Transmission and Distribution of Electricity at the Royal Docks," by F. W. Sheppard. North-East London Branch. Angel Hotel, Ilford. Mon., Dec. 6, 8 p.m.
LEEDS
"Fluorescent Applications of Electricity," by R. Pye. Leeds Branch. Great Northern Hotel, Leeds. Mon., Dec. 6, 7.30 p.m.
YORK
"Outdoor Lighting," by J. Howell. York Branch. Picture House Café, Coney-street, York. Wed., Dec. 8, 7.15 p.m.

British Institution of Radio Engineers

NEWCASTLE-UPON-TYNE
"Logic, Algebra and Relays," by Professor Emrys Williams. North-Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Dec. 8, 6 p.m.
WOLVERHAMPTON
"Industrial Applications of Electronic Control," by J. A. Sargrove. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Dec. 8, 7.15 p.m.

Chemical Engineering Group

LONDON
"Value of Work Study to the Chemical Industry," by J. Grange Moore. University College, Gower-street, W.1. Mon., Dec. 6, 6.30 p.m.

Chemical Society

EDINBURGH
"Recent Researches in Crystallography," by Professor Kathleen Lonsdale. Edinburgh Branch. North British Station Hotel, Edinburgh. Thurs., Dec. 9, 7.30 p.m.
HULL
"Chemotherapy and Essential Trace Elements," by Professor Adrian Albert. Hull Branch. Chemistry Department, The University, Hull. Thurs., Dec. 9, 7.30 p.m.

Engineers' Guild

LONDON
Annual General Meeting. 16 Queen Anne's-gate, Westminster, S.W.1. Wed., Dec. 8, 5.45 p.m.

Illuminating Engineering Society

MANCHESTER
"Studies in Interior Lighting," by J. M. Waldram. Manchester Centre. Offices of the North-Western Electricity Board, Town Hall, Manchester. Thurs., Dec. 9, 6 p.m.
NEWCASTLE-UPON-TYNE
"Fluorescent Stage Lighting and Other Applications of Fluorescent Lamp Dimming," by H. H. Ballin. Newcastle Centre. Newe House, Pilgrim-street, Newcastle-upon-Tyne. Wed., Dec. 8, 6.15 p.m.

Incorporated Plant Engineers

LONDON
"Heat Treatment of Steel," by C. Haywood. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Dec. 7, 7 p.m.
EDINBURGH
"Lighting in Industry," by Charles J. King. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Dec. 7, 7 p.m.
LEEDS
Film Evening. West and East Yorkshire Branch. Great Northern Hotel, Leeds. Fri., Dec. 10, 7.30 p.m.
NEWCASTLE-UPON-TYNE
Film Evening. North-East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Dec. 9, 7 p.m.
NOTTINGHAM
"History and Development of Displacement Pumps," by W. R. Groves. East Midlands Branch. Adult Education Centre, Shakespeare-street, Nottingham. Wed., Dec. 8, 7 p.m.

Institute of British Foundrymen

ACCRINGTON
"Metallurgical Control in a Foundry," by E. R. Hodgson. Burnley Section. Accrington Grammar School, Blackburn-road, Accrington. Wed., Dec. 8, 7.30 p.m.
BRADFORD
"Moulding," by L. L. Allard. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Dec. 11, 6.30 p.m.
GLASGOW
"Production of Castings for a Specialised Industry," by R. R. Taylor. Scottish Branch. Royal Technical College, Glasgow. Sat., Dec. 11, 3 p.m.
NEWCASTLE-UPON-TYNE
Films, introduced by R. W. Mann. Newcastle Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Sat., Dec. 11, 6 p.m.
SHEFFIELD
Discussion on "Methods of Making a Typical Casting in Cast Iron." Sheffield Branch. College of Technology, Pond-street, Sheffield. Mon., Dec. 6, 7.15 p.m.

Institute of Fuel

LONDON
"Note on the 'Optimum Degree' of Coal Washing," by J. K. Matthews. Institution of Civil Engineers, Great George street, Westminster, S.W.1. Thurs., Dec. 9, 5.30 p.m.
LEEDS
"Shell- and Water-Tube Boiler Maintenance and Repair," by A. Jeavons. Yorkshire Section. Hotel Metropole, Leeds. Wed., Dec. 8, 2.30 p.m.

Institute of Marine Engineers

LONDON
"Steering Gear," by W. S. Paulin. Student Lecture. Mon., Dec. 6, 6.30 p.m.
GLASGOW
"Problems on Machinery Space Ventilation," by W. H. Glass. Scottish Section. 39 Elmbank-crescent, Glasgow, C.2. Wed., Dec. 8, 7.30 p.m.

Institute of Metals

SWANSEA
"Peace-Time Uses of Atomic Energy," by Dr. Alex. B. McIntosh. South Wales Local Section. Metallurgy Department, University College, Swansea. Tues., Dec. 7, 6.45 p.m.

Institute of Petroleum

LONDON
"Design and Operation of a Fluidised Pilot Plant for the Fischer-Tropsch Synthesis," by Dr. C. C. Hall and A. H. Taylor. Wed., Dec. 8, 5.30 p.m.

Institute of Road Transport Engineers

BRISTOL
"Metal Spraying and Building-Up Processes," by H. Payne. Western Centre. Grand Hotel, Bristol. Tues., Dec. 7, 7.30 p.m.
CARDIFF
"Exhaust Brake Design and Operation," by W. K. Cox and A. J. Slee. South Wales Group. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Dec. 9, 7 p.m.
GLASGOW
"Electrical Equipment as Applied to the Heavy Commercial Vehicle," by C. T. Corney and A. V. Waters. Scottish Centre. 39 Elmbank-crescent, Glasgow, C.2. Mon., Dec. 6, 7.30 p.m.
NOTTINGHAM
"Organisation and Operation of a Large Composite Fleet," by R. H. Patman. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., Dec. 8, 7.30 p.m.
PRESTON
"Diesel Maintenance," by H. L. Parrish. North-West Centre. Victoria and Station Hotel, Preston. Tues., Dec. 7, 7.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"Synthetic Acetic Acid," by R. Page. Midlands Branch. The University, Edmund-street, Birmingham. Sat., Dec. 11, 3 p.m.
MANCHESTER
"Vapour and Gas Evolution from Low-Vapour-Pressure Liquids," by G. Burrows and F. H. Preece. North-Western Branch. College of Technology, Manchester. Sat., Dec. 11, 3 p.m.

Institution of Civil Engineers

LONDON
Symposium on High Buildings. Speakers: Sergei Kadleigh, Professor A. L. L. Baker, Dr. A. W. Skempton and S. J. Chamberlain. Tues., Dec. 7, 5.30 p.m.
BIRMINGHAM
"Transport Helicopter," by R. H. Whitby. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham. Thurs., Dec. 9, 6 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "The Applications and Limitations of Electronic and Other Computers," opened by Dr. L. G. Brazier. Mon., Dec. 6, 5.30 p.m.
"Fluorescent Lighting Control Circuits," by G. V. McNeil. London Students' Section. Tues., Dec. 7, 6.30 p.m.
Discussion on "Kinetic Theory of Gases for Engineering Students," opened by Dr. M. R. Gavin. Education Discussion Group. Wed., Dec. 8, 5.30 p.m.
"A Brushless Variable-Speed Induction Motor," by Professor F. C. Williams and E. R. Laithwaite, Utilization Section. Thurs., Dec. 9, 5.30 p.m.
BIRMINGHAM
"Technical Arrangements with the Sound and Television Broadcasts of the Coronation Ceremonies on June 2, 1953," by W. S. Proctor, M. J. L. Pulling and F. Williams. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Dec. 6, 6 p.m.
BRIGHTON
"Safety in the Use of Portable and Transportable Electrical Equipment in Industry," by J. W. Bunting. Southern Centre. Technical College, Brighton. Wed., Dec. 8, 6.30 p.m.
DERBY
"High-Altitude Testing of Aircraft Electrical Machines," by R. F. Sims. East Midland Centre. East Midlands Electricity Board's Offices, Derby. Tues., Dec. 7, 6.30 p.m.
LEEDS
"Design Features of the Semi-Outdoor Power Station at Ince," by F. H. S. Brown. North Midland Centre. Yorkshire Electricity Board's Offices, 1 Whitehall-road, Leeds. Tues., Dec. 7, 6.30 p.m.
LIVERPOOL
Faraday Lecture on "Courier to Carrier in Communications," by T. B. D. Terroni. Mersey and North Wales Centre. Philharmonic Hall, Liverpool. Mon., Dec. 6, 6.30 p.m
MANCHESTER
"Electrification of the Manchester-Sheffield-Wath Lines, Eastern and London Midland Regions, British Railways," by J. A. Broughall and K. J. Cook. North-Western Centre. Engineers' Club, Manchester. Tues., Dec. 7, 6.15 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Control of Electrical Circuits," by J. Teasdale. North-East Branch. Northern Architectural Association's Hall, 6 Higham-place, Newcastle-upon-Tyne. Mon., Dec. 6, 7.15 p.m.

Institution of Engineering Inspection

LONDON
Film Evening. Royal Society of Arts, John Adam-street, W.C.2. Wed., Dec. 8, 6.45 p.m.

Institution of Engineers and Shipbuilders in Scotland

ABERDEEN
"High-Pressure Boilers," by T. Carlile. Robert Gordon's Technical College, Aberdeen. Fri., Dec. 10, 7.45 p.m.

Institution of Locomotive Engineers

LONDON
"Materials Used in Locomotive, Carriage and Wagon Construction," by A. Turner. Institution of Mechanical Engineers, 1 Birdcage-walk, S.W.1. Wed., Dec. 8, 5.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Recruitment to the Engineering Profession from the Secondary Grammar Schools." Education Group. Tues., Dec. 7, 6.45 p.m.
"Cylindrical Pressure Vessels: Stress Systems in Plain Cylindrical Shells and in Plain and Pierced Drumheads," by Dr. W. B. Carlson and J. D. McKean. Fri., Dec. 10, 5.30 p.m.

Institution of Production Engineers

CHATHAM
"Shell Moulding," by M. C. Dixon and R. S. Bushnell. Rochester Section. Sun Hotel, Chatham. Thurs., Dec. 9, 7.30 p.m.
CHELMSFORD
"Shell Moulding," by M. C. Dixon and R. S. Bushnell. South-Essex Section. Mid-Essex Technical College, Chelmsford. Wed., Dec. 8, 7.30 p.m.
LEICESTER
"Training as Related to Production Processes," by E. M. Price. Leicester Section. Bell Hotel, Leicester. Thurs., Dec. 9, 7 p.m.

Institution of the Rubber Industry

GLASGOW
"Silicone Rubber," by J. H. E. Jeffes. Scottish Section. 39 Elmbank-crescent, Glasgow, C.2. Tues., Dec. 7, 7.30 p.m.
LIVERPOOL
"Using Man-Made Fibres in the Rubber Industry," by Dr. J. W. Illingworth. Merseyside Section. 24 Hatton-garden, Liverpool. Mon., Dec. 6, 7 p.m.

Institution of Structural Engineers

MIDDLESBROUGH
"Steelwork for Hindhaugh Street Flats, Newcastle," by E. Czeiler. Northern Counties Branch. Cleveland Scientific and Technical Institute, Middlesbrough. Tues., Dec. 7, 6.30 p.m.
SWANSEA
"Developments in the Structural Use of Concrete," by H. E. Lewis. Wales and Monmouthshire Branch. Mackworth Hotel, Swansea. Wed., Dec. 8, 6.30 p.m.

Junior Institution of Engineers

LONDON
Presidential Address on "Engineering in the Twentieth Century," by Professor S. J. Davies. Fri., Dec. 10, 7.30 p.m.

Reinforced Concrete Association

LONDON
"Load Factor Methods of Designing Reinforced Concrete," by Dr. F. G. Thomas. 11 Upper Belgrave-street, S.W.1. Wed., Dec. 8, 6 p.m.

Royal Aeronautical Society

LONDON
"Problems of Structural Design," by D. James. Thurs., Dec. 9, 7 p.m.

Royal Institution

LONDON
"Coal and Smokeless Fuels," by Sir Charles Ellis. Fri., Dec. 10, 9 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"Parkgate 11-in. Continuous Bar Mill," by W. Udall. Annual Meeting. The University, St. George's-square, Sheffield. Mon., Dec. 6, 7.30 p.m.

Society of Engineers

LONDON
"Aluminium as a Bridge Material," by Cedric Marsh. Geological Society, Burlington House, Piccadilly, W.1. Mon., Dec. 6, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 4893.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1. (ABBey 3794.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's-square, Sheffield, 1. (Sheffield 24071.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)